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CONTENTS

Article		*Page*
9.	**Tokioka, T.**: Invertebrate fauna of the intertidal zone of the Tokara Islands. I. Introductory notes, with the outline of the shore and the fauna.	123
10.	**Tokioka, T.**: Ditto. II. Record of the stranded floating animals.	139
11.	**Tokioka, T.**; Ditto. III. Echiuroidea and Sipunculoidea.	140
12.	**Tokioka, T.**: Ditto. IV. Preliminary list of the collection of Brachyura and Stomatopoda.	141
13.	**Tokioka, T.**: Ditto. V. Echinodermata.	144
14.	**Utinomi, H.**: Ditto. VI. Alcyonaria.	149
15.	**Habe, T.**: Studies on the eggs and larvae of the Japanese gastropods (4).	161
16.	**Habe, T.**: Notes on the type specimens of three species of Japanese molluscs described by F. Jousseaume.	169
17.	**Yamazi, I.**: Plankton investigation in inlet waters along the coast of Japan. IX. The plankton of Onagawa Bay on the eastern coast of Tôhoku district.	173
18.	**Yamazi, I.**: Ditto. X. The plankton of Kamaisi Bay on the eastern coast of Tôhoku district.	189
19.	**Baba, K.**: Three new species and two new records of the genus *Glossodoris* from Japan.	205
20.	**Mawatari, S.**: Studies on Japanese Ctenostomatous Bryozoa. I. On some species of Carnosa.	213
21.	**Yamaguti, S.**; Parasitic copepods from fishes of Japan. Part 7. Cyclopoida, III and Caligoida, IV.	221

Record of Works. (for 1952). 233

INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

I. INTRODUCTORY NOTES, WITH THE OUTLINE OF THE SHORE AND THE FAUNA[1)2)]

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With Plates IV–VI and 6 Text-figures

A scientific research party, associated under the management of Mr. Yoshitaka TSUTSUI, director of the Osaka City Museum of Natural History, visited the Tokara Islands and undertook careful researches in each special field of sciences during the period from June 26 to July 12 of 1953. The Tokara Islands consists of 10 small islands stretching in a series between the southern end of Kyûsyû and Okinawa, just in the range from 29° to 30°N. (Fig. 1), and is of special interest to biologists of this country by the fact that the northern limit of the distribution of some tropical animals and plants and the southern limit of the distribution of some boreal animals and plants are found in or near these islands. However, no comprehensive biological survey has previously been carried out there.

Fortunately I had an opportunity to join this party and engaged myself in collecting and studying the invertebrate animals in the intertidal zone of the Islands. The biological party first visited Takarazima (Pennell or Roy Island), the southern-most one of this islands group, and then Nakanosima (Pinnacle Island) which is the largest main island and is situated near the northern end of the group. Thus, we may be able to make a comparison between the faunae and florae of northern and southern ends of the Islands.

As our sojourn on each island was limited to 7–10 days, I was not able to extend the scope of the observation and collection below the low water mark. Thus, the survey was confined to the invertebrate animals excepting insects inhabiting in the intertidal zone, in small or shallow tide pools or under stones in pools. At Takarazima,

1) Scientific Survey of the Tokara Islands, Report No. 2.
2) Contributions from the Seto Marine Biological Laboratory, No. 208.

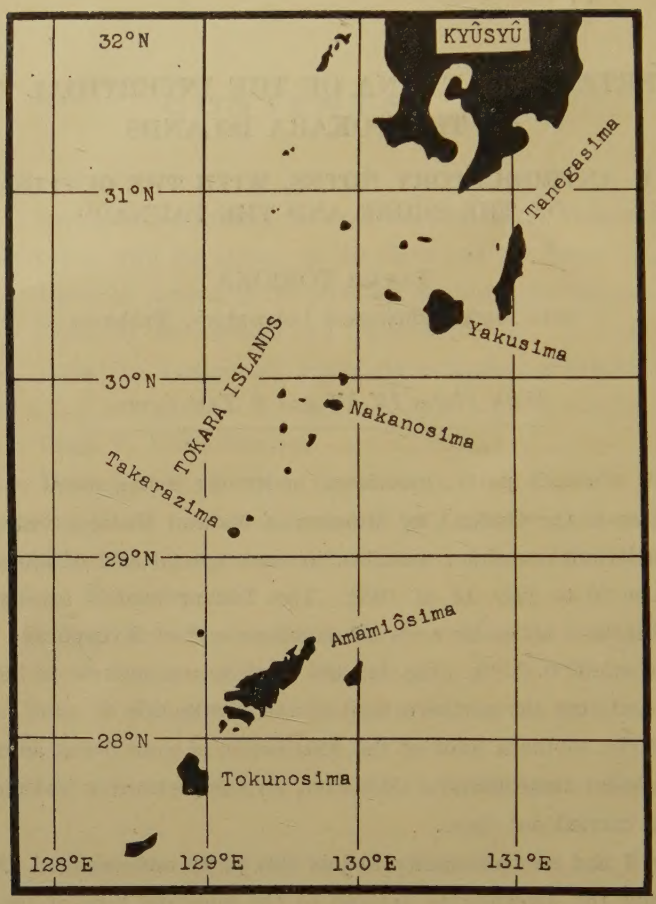


Fig. 1. Map of the Tokara Islands.

I could explore along nearly all the coast of the island and succeeded to obtain some satisfactory results. At Nakanosima, however, the fringing reef or the low-water abrasion bench is not so developed as in Takarazima, except for a part of the southern coast; the coast is steeply cliffed at many places and refuses our approach. Moreover, a heavy weather in the beginning of the rainy season prevented much our active works. Thus, I could observe and collect the animals only at several stations; the fauna and flora of the whole island remains almost unexplored. For these reasons, I prefer to note at first on the invertebrate fauna on the reef of Takarazima and then make mention of that of Nakanosima, comparing it with that of Takarazima.

Besides my own collection, many precious specimens were offered me by other members of the party. Many peoples of the islands helped us much in collecting the material. The specimens, thus gathered, were classified and some of them were already

sent to specialists for identification and preparing the lists and informations which will be published in reports of this series.

The invertebrate fauna of the coral reef of these islands, as might be expected, is of tropical nature. It is, however, too ambitious to consider the fauna reported here as invariable. Seasonal change of climate and the periodicity of the breeding season in some animals are naturally expected in this region. Consequently, I hope that the intertidal fauna of these islands, preliminarily reported here, may be accepted merely as a phase in the annual succession.

1. General Feature of the Invertebrate Fauna on the Coral Reef of Takarazima

Along the whole 12 km long coast around the island, the raised fringing coral reef is exposed at low tide (Fig. 2). The reef is about 100 m broad and built entirely with dead and dark-coloured corals. The island itself is a raised reef, about 300 m at the highest point and bordered with a plane meadow, the seaward edge of which is quite rocky and so rugged that it is very hard to walk upon. The high water mark

Fig. 2. Map of Takarazima.

is discerned here. The surface of the reef becomes gradually even to the seaward edge of the reef till it forms at last a wide flat where many boat channels are running in from the margin of the reef. The larger channels which allow the passage of native boats are called "Komori" (*komoru*=to harbour in Japanese), while the smaller channels are named "Yato" by inhabitants. The bottom of narrow Yato is considerably widened, eroding the reef and forms the caves under the water. There are many pools of various sizes and depths on the reef. The most strange arrangement of pools is found at the south-eastern part of the island, where many shallow pools are arranged as the paddy fields in this country.

When the exposed reef at low tide is viewed from the height, it will be clearly seen that the reef can be divided into the following four zones in respect to the colouration. They are the grayish zone along the high water mark, the yellowish zone below the precedence and next the purplish zone, followed by the brownish zone which fringes the seaward edge of the reef (Pl. IV). This division seems to be of a general character applicable to all around the island. The brownish zone may come deeply into the reef along the Yato and Komori. In several places, the sandy beach is formed above the grayish zone. Especially it is developed remarkably at the north-east part of the island and called "Sabaku" which means the desert in Japanese; here is a thicket of *Pandanus tectorius* SOLANDET. The sands consist chiefly of coral sands mingled with a small amount of tiny shell fragments and foraminiferan shells *Baculogypsina* (Fig. 6) and *Orbitolites*. In the following, the general character of the fauna in each zone is described briefly.

Beach area above the grayish zone.

The land hermit crabs, *Coenobita* spp., are the commonest inhabitants in and near the thicket of *Pandanus*. A species of land crab with purplish chelae, *Geograpsus lividus stormi* DE MAN, is found frequently near the thicket and lodging in holes in the sandy banks. *Tylos granulatus* MIERS is buried in sand and a few individuals of *Orchestia* spp. are often met with under the stranded sea-weeds and dusts. Many shallow pools are scattered in the meadow near the grayish zone, holding the fresh water in the surface layer and the brackish water in the bottom. *Aëdes* larvae and tadpoles of *Polypedates japonicus* (HALLOWELL) are found commonly in these pools and a species of harpacticid copepod, *Tigriopus japonicus* MORI and some amphipods are also discovered in some of these pools.

Grayish zone.

The colour of this zone seems to be the natural hue of dead corals. A conspicuous littorinid-zone can be discriminated in the upper part commonly wetted by the sprays of waves. This zone is characterized by the dense population of the single species,

Tectarius (*Nodilittorina*) *vilis* (MENKE), although I found only three individuals of *Tectarius* (*Nodilittorina*) *granularis* GRAY in this zone at Akûki Saki and an individual of *Littoraria pintado* (WOOD). On the east side of Sagiga Saki, *Melarhaphe* (*Littorinopsis*) *obesa* (SOWERBY) is found here and there above the littorinid-zone. This smart littorinid, faintly coloured violet, could also be found rarely on the southern coast at Ôse and Akêgora. Below the littorinid-zone, the *Chthamalus-Siphonaria*-zone is discernible. The barnacle is represented by the single species, *Chthamalus intertextus* DARWIN which has the shell coloured internally violet. Siphonarians observed here belong to a single species, *S. rucuana* PILSBRY. *Ostrea* (*Lopha*) *cucullata* BORN is found sparsely between the *Chthamalus-Siphonaria*-zone and the upper part of the following yellowish zone.

Near Maégomori, a large Komori near the middle of the northern coast, the grayish zone slopes sharply and in many places is represented by the surface of the cliff, the lower part of which is evidently in the yellowish zone. Here many small neritid snails, *Nerita* (*Ritena*) *plicata* LINNÉ, *Nerita* (*Ritena*) *helicinoides laevilabris* PILSBRY, *Nerita* (*Ritena*) *undata striata* BURROW and *Nerita* (*Amphinerita*) *polita* LINNÉ, are attached to the surface. Numerous rock-slater, *Megaligia exotica* (ROUX), are running around the wide range from the area above the high water mark to the yellowish zone. A large muddy coloured crab, *Geograpsus crinipes* (DANA), may be found near the high water mark.

Yellowish zone.

This zone merges completely under the water at high tide; its yellowish colouration is probably attributable to the presence of some lower algae on the surface of the reef. The surface is somewhat rugged in places, but as a whole considerably smoothed as compared with the grayish zone. Tide pools are exposed here and there at low tide. At the time of our visit, many small Ulvaceae chiefly consisting of *Ulva conglobata* KJELLMAN were growing widely in this zone. The most remarkable sedentary animal is *Tetraclita squamosa* which contains the reddish subspecies *formosana* HIRO and the greenish subspecies *viridis* DARWIN. Near Hutamatatati on the south-eastern coast and Akûki Saki, a great many individuals of small blackish cerithiids are found in shallow pools in the upper part of this zone; their empty shells are stranded numerously upon the grayish zone. Muricid snails, *Drupa* (*Morulina*) *granulata* (DUCLOS) and *Thais* (*Mancinella*) *distigmuenda* (DUNKER & ZELEBOR) appear in the lower part. The fauna in pools in the yellowish zone is very poor, only some gobiid and blenniid fishes are the common inhabitants. In deeper pools, however, we can hear the crack of a squill, *Gonodactylus chiragra* FABRICIUS. I must confess here that I am also one of the sufferers who have get an enormous mitten of this animal on the glass vessel. The wall of the glass tube was finely punched at a blow. On the undersurface of

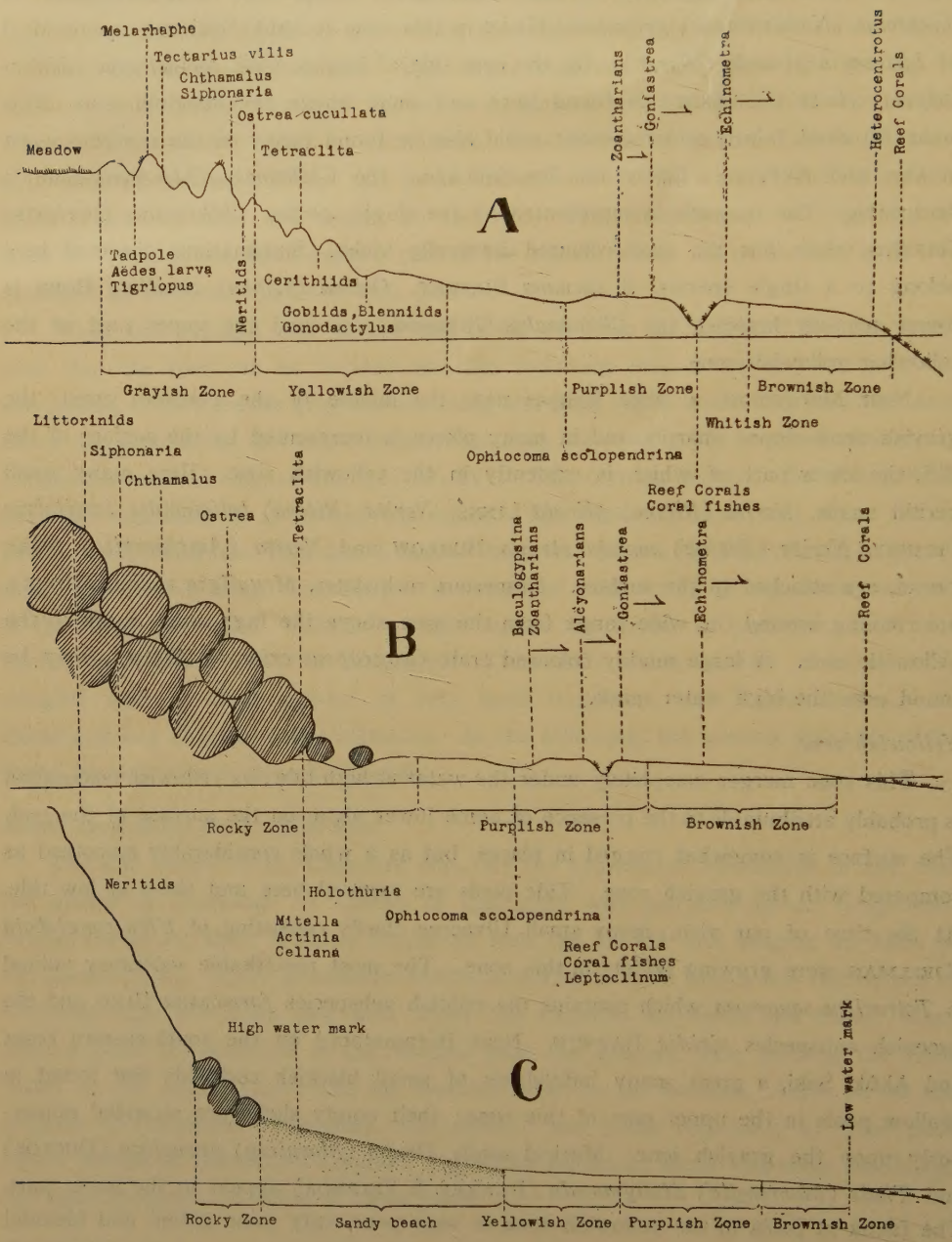


Fig. 3. Schemata of optical sections of the shore of Takarazima (A), shore of the western coast of Nakanosima (B) and that of the eastern coast of the same island (C).

stones in deep pools, we can see isognomonid bivalves, sponges, ascidians—*Ascidia aperta* SLUITER and whitish didemnids, small chiton *Ischnochiton comptus* (GOULD) and small isopods like *Sphaeroma*, etc. *Ascidia aperta* varies conspicuously in colour from colourless transparent to reddish orange. Besides, the following tiny snails: *Bothropoma*? *granulosum* (PEASE), *Philbertia chichijimana* PILSBRY var., *Planaxis* (*Angiola*) *viratus* SMITH and *Pyrene* (*Zatra*) *sinensis* (SOWERBY) are found commonly under stones. A large crab running rapidly on the reef is *Grapsus strigosus* HERBST, edible and most useful as bait in this island.

Purplish zone.

The surface of the reef becomes in this zone quite even and is covered by a species of Melobesiae, *Porolithon* sp. which colours the surface gray purplish. Slight depressions retaining moisture during the ebb tide are crowded with colonies of grayish *Zoanthus* sp., the oral disc of which is expanded in the water and shows a pretty pinkish or greenish striations. Other zoantharians such as *Palythoa* spp. and *Isaurus* sp. appear along the margin of pools or Yato. There are found two distinct species in *Palythoa*; one is provided with a well-developed coenenchyme and at a glance reminds us of a species of astraeid corals, while the other has extremely thin coenenchyme and resembles the common *Zoanthus*. The former is whitish yellow or yellowish brown in colour when exposed, but in the water it changes to reddish brown by the expansion of the oral disc. The latter is brownish externally and dark greenish on the oral disc. *Isaurus* shows a wide range of variations in colour, greenish to brownish, and in size of tubercles; some specimens are nearly devoid of these knobs. All these zoantharians together with some alcyonarians known usually as "soft corals" are called "Naba" by inhabitants, which means the mushroom in some districts of Japan. A species of reef corals, *Goniastrea aspera* VERRILL may be seen commonly mingled with these Naba. In addition, the following nine corals may be exposed along the margin of deep pools, Yato and Komori and on the slope along the reef margin at low tide.

Porites cf. *haddoni* VAUGHAN
Acropora abrotanoides (LAMARCK)
Acropora (? *abrotanoides* var.)
Acropora pectinata (BROOK)
Acropora (*Tylopora*) *scherzeriana* (BRÜGGEMANN)
Psammocora gonagra KLUNZINGER
Coeloseris mayeri VAUGHAN
Pocillopora verrucosa (ELLIS & SOLANDER)?
Pocillopora damicornis (LINNÉ)

In the lower part of this zone, a narrow whitish zone marked by a white *Porolithon* sp. can be discerned at several stations, although the distinction is possible rather with some difficulties. When we break the surface of the reef near the whitish zone, we can find under the thin layer of the purplish *Porolithon* many nest tubes of a sedentary polychaete, *Pomatoleios crosslandi* PIXELL, and numerous sipunculids, such as *Phascolosoma albolineatum* (BAIRD), boring below the nest tubes of *Pomatoleios*. This sipunculid often extrudes its proboscis which is marked conspicuously with white and reddish brown—dark brown bands out of the hole under the strong sun-shine at ebb tide. Abundant brittle stars, *Ophiocoma scolopendrina* (LAMARCK), *Holothuria* (*Holothuria*) *atra* JAEGER covered with sand grains over the body surface and *Holothuria* (*Holothuria*) *vagabunda* SELENKA without sandy coat appear in shallow pools in this zone. Several species of Polyclada are also met with frequently near the shallow pools.

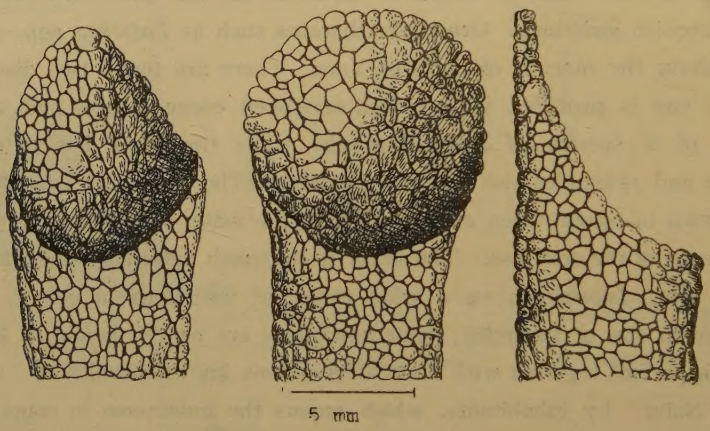


Fig. 4. Opening of the nest tube of *Idanthyrsus pennatus* (PETERS). The left two viewed from below, the right one shows the lateral side.

Next comes the turn to look in large and deep pools and Yato. The wall is beautifully painted with sea-weeds, green by *Halimeda*, *Caulerpa*, *Dictyosphaera*, *Valonia* and *Chlorodesmis*, grayish violet by *Mastophora* and *Liagora* and red-scarlet by *Cheilosporum*, *Galaxaura* and some species of Melobesiae. The sponges add yellow, violet, red and black to this colouration and some compound ascidians, *Leptoclinum* and *Didemnum*, harbouring zoochlorellae in lacunae of the colony, add bluish green—whitish green. Small but very pretty violet hydrocoral, *Distichopora violacea* (PALLAS) may be found among these algae and animals. *Ophiomastix annulosa* (LAMARCK), larger than *Ophiocoma scolopendrina* and coloured grayish on the aboral and reddish orange on the oral side, may be commonly found in these pools. Several individuals

of a tropical sea anemone, *Thalassianthus aster* LEUCKART was found in the cleft of the reef near Ôse. Scarlet *Dendrophyllia* decorates the walls of narrow and dark Yato or clefts of pools. Many reef corals varying in colours and shapes are growing in the water and various coral fishes are swimming among them like butterflies.

There are many pot-like small depressions on the reef, in which we can find the openings of the nest tubes of a sedentary polychaete *Idanthyrsus pennatus* (PETERS) (Fig. 4), reddish orange *Ascidia aperta* and yellowish orange sponge, *Tethya* sp. Many of minute crabs, *Pachygrapsus minutus* A. M. EDWARDS are running around there for searching food; *Eriphia laevimana* LATREILLE with red eyes and *E. scabricula* DANA are also the common crabs in this region.

Gastropods found here are all of tropical nature; important species are listed below:

Muricidae:

Drupa morum RÖDING

Drupa albolabris (BLAINVILLE)

Drupa ricina (LINNÉ)

Buccinidae:

Engina mendicaria (LINNÉ)

Mitridae:

Mitra (*Strigatella*) *virgata* (REEVE)

Mitra (*Strigatella*) *litterata* (LAMARCK)

Mitra (*Strigatella*) *decurtata* (REEVE)

Conidae:

Conus (*Virroconus*) *ebraeus* LINNÉ

Drupa morum, the most remarkable muricid with violet aperture, was rather rare in the range between Maégomori and Tô Saki. *Thais* (*Mancinella*) *armigera* (DILLWYN) is said to climb up the wall of Yato at low tide. Most of hermit crabs found in this zone are coloured brightly. Most impressive animal near the whitish zone is a species of phyllodocid polychaete, which is extremely slender reaching ca. 700 mm in length and creeping actively when the water washes this zone.

Brownish zone.

The purplish zone is altered to the brownish zone by the vegetation grown on its surface. This vegetation consists of small Gelidiaceae and their youngs and other Rhodophyceae such as *Hypnea*, *Dictyocha* etc. and forms a sort of mat covering this area. Large disc-shaped foraminiferan *Orbitolites complanata* LAMARCK is found commonly attached to these small algae. The fauna of this zone is nearly the same as in the preceding zone excepting the increase of small pocket-like depressions, in which

always one elliptical sea urchin, *Echinometra mathaei* (BLAINVILLE), can be found. It is a noteworthy fact that darkly coloured individuals of *Echinometra mathaei* are found much more frequently than whitish individuals near the reef edge, while the former is much fewer than the latter in the part distant from the reef edge. The slope along the reef margin is covered by various reef corals, among which we can find some soft corals, *Lobophytum*, *Microspicularia*, etc., and *Heterocentrotus mammillatus* (LINNÉ); the last-named urchin is familiar to the inhabitants of the island by its thick pipe-like spines and distributed in the range between Maégomori and Tô Saki. *Microspicularia* catches our eyes by its rapid change of colour which is brownish in the water, while passes immediately into white when exposed.

Sandy zone.

There are several narrow sandy zones which merge under the water at high tide. Besides, some pocket zones in the reef keep a considerable amount of sand in them. *Ocypoda* sp. is a sole crab inhabiting in the upper part of the sandy zone. *Asaphis dichotoma* (ANTON), *Venus* (*Periglypta*) *reticulata* LINNÉ and *Arcopagia* (*Scutarcopagia*) *scobinata* (LINNÉ) are the bivalves found in sandy zones. A considerable number of *Siphonosoma cumanense* (KEFERSTEIN), one specimen of *Ochetostoma erythrogrammon* LEUCKART & RÜPPELL and an individual of small and yellow enteropneust were collected from the sandy zone of this island.

The zonation mentioned above is shown schematically in Fig. 3 A. At first, I was rather disappointed when I reached to the reef and surveyed the grayish—yellowish zones where the surface of the reef was rather bare and the fauna was very poor. But, according to approach to the purplish—brownish zones, I was impressed much by the tropical feature of the fauna and flora. At last I was fascinated completely when I looked into the deep pools, Yato and the water at the reef edge. How many other tropical animals does this sea conceal under the water?

2. General Feature of the Invertebrate Fauna in the Intertidal Zone of Nakanosima

Nakanosima is a volcano island. The main peak is Mt. Otake 1030 m high, a dormant volcano still jetting vapour and sulphurous gas from several spots near the apex (Fig. 5). The coast line of this island is twice and a half as long as that of Takarazima. We could not explore along the whole coast as already mentioned, but only along the coast near Miyazuru from Amadomari to Sii Saki on the south-western coast and the coast near Nanatuyama Ura on the eastern coast.

Western coast.

Large rocks of augite-andesite fill up the whole beach and a narrow raised coral

reef fringing the coast below the rocky zone may be exposed at low tide in some places. This reef represents the part lower than the purplish zone in Takarazima. The rocky zone is substituted in many places for the part upper than the yellowish zone in Takarazima. Pools and clefts on the reef are comparatively few and are not well developed as in Takarazima. Moreover, there are wide areas covered by sand, the accumulation of which is especially remarkable near Amadomari at the northern part of the surveyed area. Here, the sand is kept tightly on the reef by the complexly

Fig. 5. Map of Nakanosima.

entangling thin nest tubes of a chaetopterid polychaete. In such sandy heaps, we can find sipunculids, enteropneust, small crab *Euplax* sp., and a cucumariid holothurian *Phyllophorus fragilis* MITSUKURI & OHSHIMA. The fauna on the reef is almost the same as in Takarazima except for the following several features.

1. The surface of the reef is densely crowded by a stellate species of Foraminifera, *Baculogypsina* sp. (Fig. 6).
2. A compound ascidian, *Leptoclinum* sp., which harbours zoochlorellae in the lacunae and is coloured blue and green, is commonly found in nearly all shallow pools and on the wall of deep pools.
3. *Palythoa* and *Isaurus* are very rare, while alcyonarians such as *Sarcophyton*

spp., *Clavularia inflata* and *Lobophytum* spp. etc., are much more abundant than in Takarazima.

4. Of the reef corals, *Goniastrea aspera* is exposed near the reef margin. Besides, only *Acropora abrotanoides* can be seen along the reef edge at low tide.
5. *Ophiocoma scolopendrina* is very abundant as in Takarazima, while the living muricids, conids and other snails which are found commonly on the reef of Takarazima are rather scarce. *Heterocentrotus mammillatus* may be found along the reef margin, but it is extremely rare.

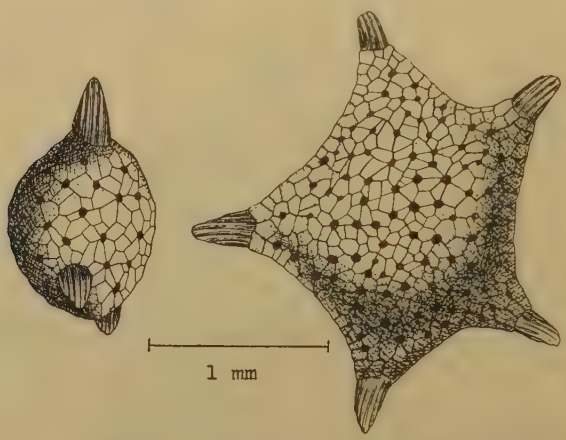


Fig. 6. *Baculogypsina sphaerulatus* (PARKER & JONES).

On the undersurface of stones in pools, we can find easily isognomonid bivalves, *Ischnochiton comptus* and white or pinkish didemnid ascidians, but no *Ascidia aperta* which is the common solitary ascidian in Takarazima. The fauna in the rocky zone differs considerably according to places. Probably the existence of the reef or the river may play a significant role. At the anchorage of Miyazuru, the following zones are discernible:

Upper part
↓ Littorinid-zone
↓ *Chthamalus*-zone
↓ *Ostrea*-zone
Tetraclita-zone
Lower part

Littorinid-zone consists of chiefly *Tectarius* (*Nodilittorina*) *vilis* (MENKE) and fewer *Tectarius* (*Nodilittorina*) *granularis* GRAY and *Littoraria undulata* (GRAY), besides a small amount of *Littoraria pintado* (WOOD). *Chthamalus*-zone consists of *Chthamalus*

intertextus and a pulmonate limpet *Siphonaria subatra* PILSBRY. In the *Ostrea*-zone, a considerable number of *Ostrea* (*Lopha*) *cucullata* are found mingled with other species. *Tetraclita*-zone is formed of two subspecies of *T. squamosa* as in Takarazima, besides *Chthamalus pilsbryi* HIRO and a small amount of *Ch. malayensis* PILSBRY. Some *Pedalion acutirostre* (DUNKER) are found in crevices on rock and some *Cellana toreuma* (REEVE) adhere to the surface mingled with barnacles. The rock-slater is very common everywhere in the rocky zone. The nest tubes of *Pomatoleios* sp. may be found on the surface of rocks which form a part of the purplish zone. *Actinia equina* (LINNÉ), *Mitella mitella* (LINNÉ) and a flat barnacle *Octomeris brunnea* DARWIN are attached to the undersurface of large stones at the level of the *Tetraclita*-zone and a trochid snail *Monodonta* (*Melagraphia*) *neritoides* (PHILIPPI) is creeping there. Under small stones at this level, we can find a synaptid holothurian *Polycheira rufescens* (BRANDT), *Petrolisthes* spp. and a chiton *Ischnochiton boninensis* BERGENHAYN, besides small crustaceans such as amphipods and *Sphaeroma* sp. *Anthopleura japonica* VERRILL and *Holothuria* (*Holothuria*) *vagabunda* SELENKA are found in the water of this level. Some neritid snails migrate up or down the littorinid-zone according to the height of the water and the condition of the surf. *Nerita* (*Theliostyla*) *exuvia* LINNÉ reaches the highest level beyond the littorinid-zone, next *Nerita* (*Ritena*) *plicata* LINNÉ reaches the lower part of the littorinid-zond and followed by *Nerita* (*Theliostyla*) *albicilla* LINNÉ, *Nerita* (*Amphinerita*) *polita* LINNÉ and *Nerita* (*Ritena*) *undata striata* BURROW, etc. Near the southern village of Yoriki, *Littoraria* spp. decrease much in the littorinid-zone. There are some places where the fresh water always traces under the stones towards the sea. In such places, a zone consisting of *Melampus caffer* (KÜSTER) and *Angustasciminea castanea satumana* HABE was discovered above the littorinid-zone.

The reef disappears near Sii Saki where the coast is covered by huge rocky stones accumulated from the depths to the foot of the cliff. On these stones, the following zones are distinguishable :

Upper part
- Littorinid-zone
- *Siphonaria*-zone
- *Chthamalus*-zone
- *Tetraclita*-zone
- Purplish zone
- Brownish zone

Lower part

The littorinid-zone is completely devoid of *Littoraria* spp. ; *Tectarius* (*Nodilittorina*) *vilis* occupies clearly the upper situation than *Tectarius* (*Nodilittorina*) *granularis*

which is found merely in a small number. *Siphonaria*-zone is represented by *S. rucuana* PILSBRY, *Chthamalus*-zone is represented by *Ch. intertextus* and *Tetraclita*-zone contains some *Cellana toreuma*, *Drupa* (*Morulina*) *granulata* and *Thais* (*Mancinella*) *distinguenda*, etc. The distinction between the purplish and brownish zones is not clear in many places; the former is covered by the nest tubes of *Pomatoleios* and a purplish Melobesiae, while the latter is clothed with *Gelidium divaricatum* MARTENS and other small Rhodophyceae, which tend to occur in the submerged zone. A black helmet-shaped sea urchin, *Colobocentrotus mertensii* BRANDT, can be seen markedly on the purplish surface of the rock near the low water mark.

Eastern coast.

At Nanatuyama Ura, the sandy beach developes well below the rocky area at the foot of the cliff. The reef is gradually exposed below the sandy shore towards the offing. The upper part of the reef is the yellowish zone, here short and reddish brown *Ceramium tenerrimum* (MART.) OKAMURA and *Centroceras clavulatum* (AG.) MONT. and green *Ulva conglobata*, all smeard with sand, cover the reef surface. *Liagora* sp. increases in number in the purplish zone. The fauna of the yellowish zone was very poor, *Drupa* (*Morulina*) *granulata* seemed to be the most important animal at the time of my visit. The general appearance of the zonation observed in Nakanosima is schematically figured in Fig. 3 B and C.

3. Rough Comparison between the Intertidal Fauna of Takarazima and That of Nakanosima

When we compare the intertidal fauna of Takarazima, the southern-most island of the group, with that of Nakanosima, near the northern end of the group, the following two differences may be accepted as important ones. (1) In Nakanosima many animals familiar to us in Kyûsyû and southern Honsyû can be found rather commonly; for instance, *Tectarius* (*Nodilittorina*) *granularis*, *Cellana toreuma*, *Actinia equina* and *Anthopleura japonica*, etc. (2) *Palythoa* and *Goniastrea* are not numerous in Nakanosima and merely grown within a short distance from the low water mark. These differences are considered generally to be caused by the differences of the structure of the shore itself. But the second difference, at least, seems to be partly due to the difference of the latitudes of two islands. This consideration does not mean the existence of a remarkable difference of the water climate between the two islands. Probably the difference of the atmospheric climate during the ebb tide limits the range of the distribution of some tropical animals. So far as the littoral water or the water of different currents is not mixed together on a large scale, the change of the hydrological condition of "Kurosio" is considered very slight. For instance, the

purplish zone is retained near the Seto Marine Biological Laboratory in Sirahama below the *Ostrea-Tetraclita*-zone composed of *Ostrea* (*Saxostrea*) *echinata* QUOY et GAIMARD and *Tetraclita squamosa japonica* PILSBRY as dominant species, on the coast faced towards the open sea, though it is not so remarkable as in the southern islands. How does the difference of the atmospheric climate affect the intertidal fauna of the islands in "Kurosio"? What correlation can be find between the fauna and the latitude? Where is the boundary, in south from where the intertidal fauna loses violent modification and becomes stable as the tropical one? I hope to continue to gather the material and data in future to prepare some answers against these questions.

Acknowledgments

I owed much to Dr. H. UTINOMI in identifying various corals, alcyonarians and barnacles, to Messrs. T. HABE and T. YAMAMOTO for snails and bivalves and to Mr. E. OGATA for sea-weeds. To all these gentlemen I wish to express here my hearty thanks for their kindness.

EXPLANATION OF PLATES IV-VI

PLATE IV

PLATE V

Figs. 1–3. Nakanosima.

Fig. 1. Coast near Miyazuru, with Mt. Otake in its background.

Fig. 2. Coast near Sii Saki.

Fig. 3. Exposed reef near Miyazuru.

Figs. 4–6. Takarazima.

Fig. 4. View of the northern slope near Maégomori.

Fig. 5. Coast near Maégomori.

Fig. 6. A part of the meadow bordered with the thicket of *Pandanus*-tree, and carpeted by the convolvulus *Ipomea Pes-caprae* in front.

PLATE VI

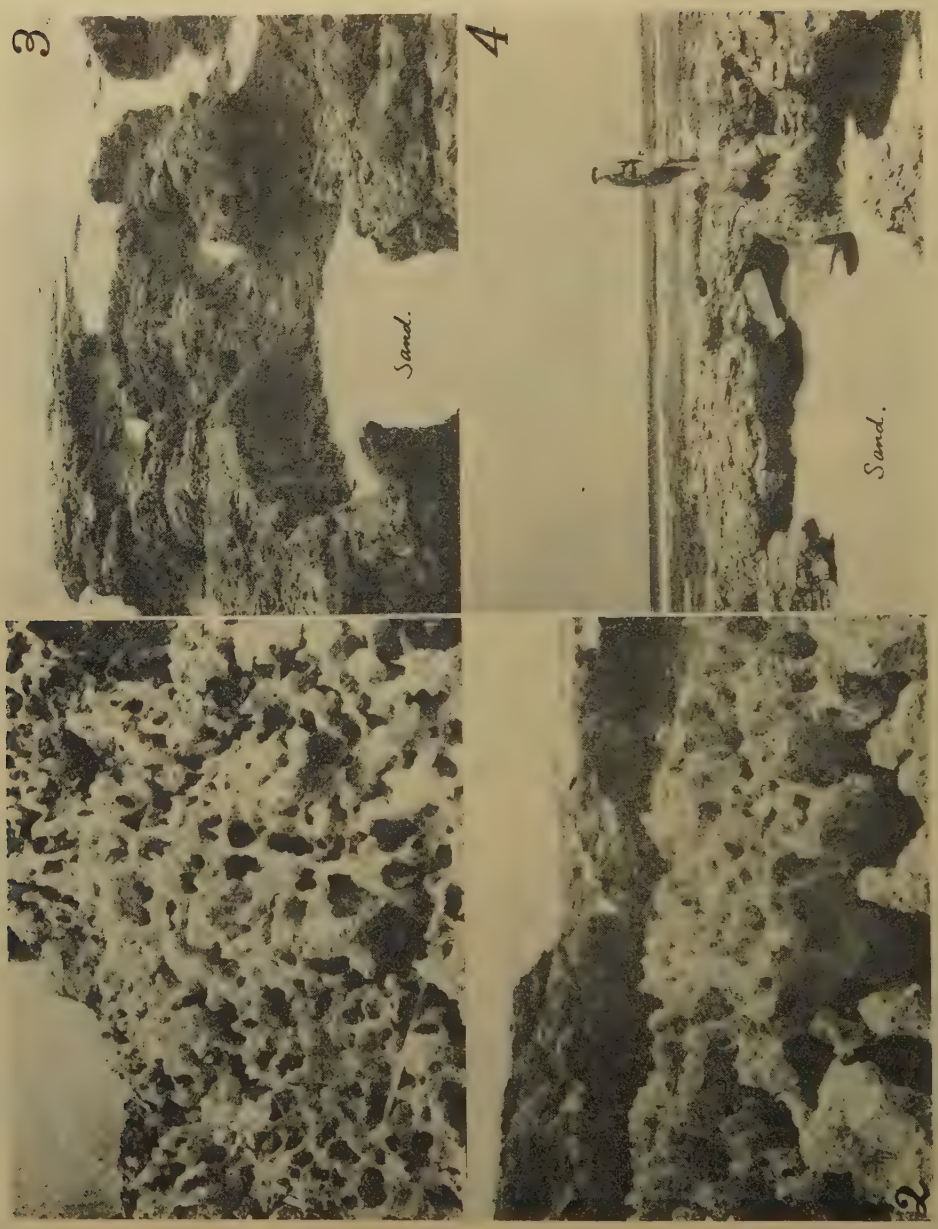
Figs. 1 and 2. Parts of the grayish zone in the shore of Takarazima.

Figs. 3 and 4. Parts of the yellowish zone in the shore of Takarazima, showing the sandy pocket-zone (3) and narrow sandy shore (4).

(All photographed by Mr. Osamu TUZIMOTO.)

A part of the exposed coral reef of Takarazima viewed from the height at ebb water. The left lower rock is a part of the yellowish zone; the purplish and brownish zones and four "Yato" are clearly shown.
(From Kagaku Asahi No. 148, Takesaburô Aoi photo.)

T. Tokioka : Invertebrate Fauna of The Tokara Islands, I.



T. Tokioka: Invertebrate Fauna of The Tokara Islands, I.

INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

II. RECORD OF THE STRANDED FLOATING ANIMALS[1) 2)]

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The following is the list of the floating animals stranded along the coasts of Takarazima and Nakanosima during my stay.

Coelenterata

1. *Velella lata* Chamisso & Eysenhardt (Takarazima & Nakanosima)
2. *Porpita umbella* O. F. Müller (Takarazima & Nakanosima)
3. *Physalia physalis utriculus* La Martiniere (Takarazima & Nakanosima)

Mollusca

4. *Janthina janthina* (Linné) (Takarazima)
5. *Janthina belteata* Reeve (Takarazima & Nakanosima)
6. *Janthina* (*Violetta*) *globosa* Swainson (Takarazima & Nakanosima)
7. *Janthina* (*Iodina*) *umbilicata* d'Orbigny (Takarazima & Nakanosima)
8. *Recluzia montrouzieri* Brazier
9. *Diacria trispinosa* (Lesueur) (Takarazima, 13 shells)
10. *Cavolinia uncinata* (Rang) (Takarazima, 2 shells)
11. *Cavolinia globulosa* (Rang) (Takarazima, 2 shells)
12. *Nautilus pompilus* Linné (Takarazima, pieces)
13. *Argonauta hians* Solander (Takarazima, one shell)

Crustacea

14. *Lepas pectinata* Spengler (Takarazima)
15. *Lepas anserifera* Linné (Takarazima & Nakanosima)

Prochordata

16. *Thetys vagina* (Tilesius) (Takarazima & Nakanosima)

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1) Scientific Survey of the Tokara Islands, Report No. 3.
2) Contributions from the Seto Marine Biological Laboratory, No. 209.

Publ. Seto Mar. Biol. Lab., III (2), 1953. (Article 10)

INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

III. ECHIUROIDEA AND SIPUNCULOIDEA[1) 2)]

TAKASI TOKIOKA
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ECHIUROIDEA

1. *Ochetostoma erythrogrammon* LEUCKART & RÜPPELL

An individual was found in the sand of a pocket zone in the reef of Takarazima. (TK. No. 1).[3)]

The northern limit of distribution in Japan: Hokkaido.

SIPUNCULOIDEA

2. *Siphonosoma cumanense* (KEFERSTEIN)

This sipunculid is commonly found in Takarazima in the sandy area on the reef. In Nakanosima, I could find only an individual in the sand. The northern limit of distribution in Japan: Aomori-ken. (TK. Nos. 2–3).

3. *Phascolosoma albolineatum* (PAIRD)

Numerously boring in the reef in the purplish-brownish zones of Takarazima and Nakanosima. The northern limit of distribution in N. W. Pacific: the southern coast of Tyôsen. (TK. Nos. 4–5).

4. *Phascolosoma scolops* (SELENKA & DE MAN)

Found with the preceding species in both Takarazima and Nakanosima, although much rarer than *Ph. albolineatum*. The northern limit of distribution in Japan: Hokkaido. (TK. Nos. 6–7).

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1) Scientific Survey of the Tokara Islands, Report No. 4.
2) Contributions from the Seto Marine Biological Laboratory, No. 210.
3) Registered number of the Tokara collections preserved in the museum of the Seto Marine Biological Laboratory.

Publ. Seto Mar. Biol. Lab., III (2), 1953. (Article 11)

INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

IV. PRELIMINARY LIST OF THE COLLECTION OF BRACHYURA AND STOMATOPODA[1)2)]

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With one Text-figure

The collection of crabs is submitted to Dr. T. SAKAI for his investigation, who will publish a complete report. Here, I give preliminarily the list of some easily identified species in the present collection with some brief notes on their habitats.

BRACHYURA

Dromiacea

1. *Petalomera fukuii* SAKAI (Takarazima, 2 individuals)

Oxystomata

2. *Calappa hepatica* LINNÉ (Takarazima)
3. *Calappa gallus* (HERBST) (Takarazima)

Brachygnatha–Oxyrhyncha

4. *Elamena truncata* (STIMPSON) (Nakanosima)
5. *Micippa platipes* RÜPPELL (Takarazima)
6. *Tiarinia cornigera* LATREILLE The dead shells are found very commonly stranded along the coast of Takarazima, while they are rather rare in Nakanosima.

Brachygnatha–Brachyrhyncha

7. *Neptunus* (*Neptunus*) *sanguinolentus* (HERBST) A chela was found in Takarazima.
8. *Charybdis orientalis* DANA (Nakanosima)

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1) Scientific Survey of the Tokara Islands, Report No. 5.
2) Contributions from the Seto Marine Biological Laboratory, No. 211.

9. *Thalamita stimpsoni* A. M. EDWARDS The carapace is greenish when alive. (Takarazima and Nakanosima, in the latter it was met with rather frequently.)
10. *Thalamita picta* STIMPSON The carapace is sandy in colour when alive. (Nakanosima)
11. *Thalamita integra* DANA (Takarazima, stranded)
12. *Carpilius maculatus* LINNÉ (Takarazima)
13. *Zozymus aeneus* (LINNÉ) (Takarazima)
14. *Daira perlata* (HERBST) (Takarazima, a stranded carapace)
15. *Xantho* (*Leptodius*)) *exaratus* (M. EDWARDS) (Takarazima, a standed carapace)
16. *Xantho* (*Leptodius*) *sanguineus* (M. EDWARDS)(The dead shells are very numerously stranded along the coasts of Takarazima and Nakanosima)
17. *Xantho* sp. (Nakanosima)
18. *Paraxanthias notatus* (DANA) (Nakanosima, 2 individuals)
19. *Carpilodes rugatus* (M. EDWARDS) Carapace purplish when alive. (Takarazima)
20. *Actaea tomentosa* (M. EDWARDS) (Takarazima)
21. *Actaea consobrina* A. M. EDWARDS (Nakanosima)
22. *Etisus* (*Etisoides*) *splendidus* (RATHBUN) (Piece of carapace, Nakanosima)
23. *Phymodius ungulatus* (H. M. EDWARDS) (Takarazima, an individual)
24. *Ozius rugulosus* STIMPSON (Takarazima & Nakanosima)
25. *Epixanthus frontalis* (M. EDWARDS) (Common in Takarazima)
26. *Epixanthus corrosus* A. M. EDWARDS (Nakanosima)
27. *Lydia annulipes* (M. EDWARDS) (The dead shells are common in Takarazima, only an individual in Nakanosima)
28. *Eriphia laevimana* LATREILLE The eyes red and the carapace grayish violet when alive. (Common in both Takarazima and Nakanosima)
29. *Eriphia scabricula* DANA (Common in Takarazima, fewer in Nakanosima)
30. *Dacryopilumnus rathbunae* BALSS (Takarazima)
31. *Pilumnus vespertilio* FABRICIUS (Takarazima)
32. *Ocypoda* sp. (In the sandy beach near Ôgomori of Takarazima)
33. *Euplax* sp. (In the sandy heaps on the reef of Nakanosima.)
34. *Grapsus grapsus tenuicrustatus* (HERBST) (A cast-off shell in Nakanosima)
35. *Grapsus strigosus* HERBST The carapace is somewhat greenish and transversely striped with thin purplish brown bands. (Numerous in Takarazima, common in Nakanosima)
36. *Geograpsus crinipes* (DANA) (Takarazima)
37. *Geograpsus lividus stormi* DE MAN (An individual from Takarazima, a chela in Nakanosima)
38. *Pachygrapsus crassipes* RANDALL (Nakanosima)

39. *Pachygrapsus minutus* A. M. EDWARDS (Very numerous in both Takarazima and Nakanosima)
40. *Pachygrapsus plicatus* (M. EDWARDS) (A cast-off shell in Takarazima)
41. *Eriocheir japonicus* DE HAAN (Nakanosima)
42. *Ptychognathus* sp. (Nakanosima)
43. *Plagusia depressa tuberculata* LAMARCK (Takarazima and Nakanosima)
44. *Percnon planissimum* (HERBST) (Takarazima and Nakanosima)

STOMATOPODA

1. *Gonodactylus chiragra* FABRICIUS Common in both Takarazima and Nakanosima. The body is usually pale yellowish brown and sprinkled with dark spots. Some specimens are, however, uniformly coloured dark green. (TK. Nos. 55–57).

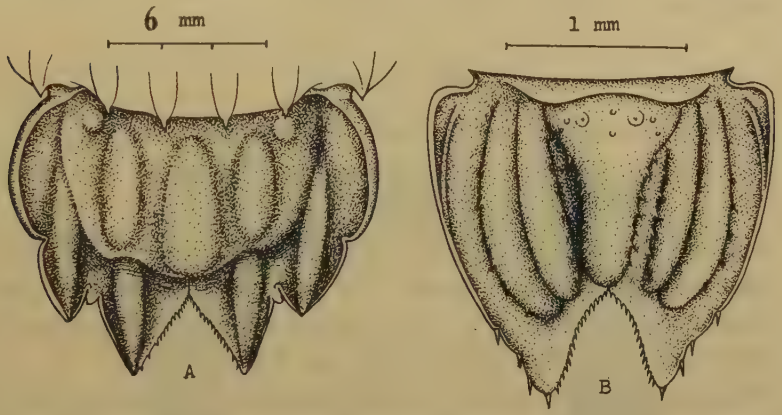

Fig. 1. Telson of *Gonodactylus chiragra* FABRICIUS (A) and *G. glabrous* BROOKS, 16mm long individual (B).

2. *Gonodactylus glabrous* BROOKS Only two small individuals were collected in Takarazima. (TK. No. 58).

12 line. For TK. Nos. 55–57 read TK. Nos. 64–66.
14 line. For TK. No. 58 read TK. No. 67.

INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

V. ECHINODERMATA[1)2)]

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With Plate VII and 3 Text-figures

CRINOIDEA

1. *Poecilometra scalaris* (A. H. CLARK) An individual in Takarazima. Dist.: South-west of Kyûsyû. (TK. No. 8).

ECHINOIDEA

2. *Plococidaris verticillata* (LAMARCK) Spines stranded in both Takarazima and Nakanosima. The northern-most locality: Kii-Ôsima (SAKAGUCHI, 1935) (TK. Nos. 21–22).
3. *Eucidaris metularia* (LAMARCK) Spines stranded in both Takarazima and Nakanosima. The northern-most locality: Kii-Sirahama (UTINOMI, 1953).
4. *Echinothrix calamaris* (PALLAS) Nakanosima. The northern-most locality: Kii-Sirahama (UTINOMI, 1953). (TK. No. 25).
5. *Tripneustes gratilla* (LINNÈ) Takarazima and Nakanosima. The northern-most locality: Kii-Sirahama (KOMAI, 1927), (TK. No. 26).
6. *Echinometra mathaei* (BLAINVILLE) Common in both Takarazima and Nakanosima. Darkly coloured individuals are distributed nearer the reef edge than whitish individuals. The northern-most locality: Simoda. (Biol. Rep. Simoda Mar. St., No. 1, 1933) (TK. Nos. 27–30).
7. *Heterocentrotus mammillatus* (LINNÉ) Takarazima and Nakanosima, in the latter it is very rare. The northern-most locality: Okinawa. (TK. Nos. 31–36).

1) Scientific Survey of the Tokara Islands, Report No. 6.
2) Contributions from the Seto Marine Biological Laboratory, No. 212.

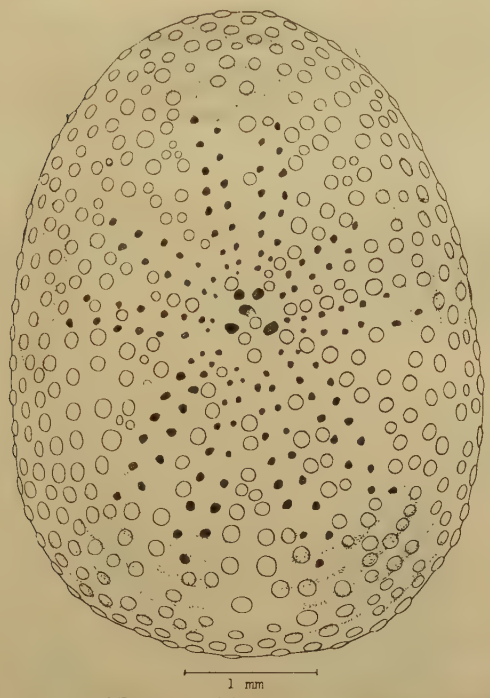


Fig. 1. *Fibularia* (*Fibulariella*) *acuta* YOSHIWARA, aboral side.

Fig. 2. *Fibularia* (*Fibulariella*) *acuta* YOSHIWARA, oral side.

8. *Colobocentrotus mertensii* BRANDT Nakanosima. The northern-most locality: Susami, Kii. (SAKAGUCHI, 1935) (TK. Nos. 37–38).
9. *Fibularia* (*Fibulariella*) *acuta* YOSHIWARA (Figs. 1 and 2) Stranded shells in Takarazima. The northern-most locality: Sendai Bay (S. NISIYAMA, 1937) (TK. No. 39).
10. *Echinoneus cyclostomus* LESKE Stranded shells in both Takarazima and Nakanosima. The northern-most locality of living form: Kagosima Bay (MORTENSEN, 1934) (TK. Nos. 40–42).

ASTEROIDEA

11. *Acanthaster planci* (LINNÉ) An individual from each of Takarazima and Nakanosima. The specimen from Takarazima bears 9 madreporites and the specimen from Nakanosima with 10 ones. The northern-most locality: Amami-Ôsima (MITSUKURI, 1906: Zool. Mag., Vol. 15, p. 242) (TK. Nos. 9–10).
12. *Asterina anomala* CLARK Takarazima. Dist.: Torres Strait (CLARK, 1921) (TK. No. 11).

OPHIUROIDEA

13. *Ophiomastix annulosa* (LAMARCK) Takarazima and Nakanosima. The northern-most locality: Pinnacle Island (H. MATSUMOTO, 1917) (TK. Nos. 12–13).
14. *Ophiocoma scolopendrina* (LAMARCK) Very common in both Takarazima and Nakanosima. The northern-most locality: Kagosima Bay (H. MATSUMOTO, 1917) (TK. Nos. 14–17).
15. *Ophiocoma erinaceus* MÜLLER & TROSCHEL Takarazima. The northern-most locality: Yaéyama Islands. (TK. No. 18).
16. *Ophiocoma parva* CLARK Takarazima. Dist.: Torres Strait (CLARK, 1921) (TK. No. 19).
17. *Ophiarachna incrassata* LAMARCK An individual was found by Dr. S. MIYAMOTO in Nakanosima. The northern-most locality: Okinawa (MATSUMOTO, 1917) (TK. No. 20).

HOLOTHURIOIDEA

18. *Holothuria* (*Holothuria*) *vagabunda* SELENKA Common in both Takarazima and Nakanosima. The northern-most locality: Kôzusima, Izu (MITSUKURI, 1912) (TK. No. 43–44).

19. *Holothuria* (*Holothuria*) *atra* JAEGER Takarazima. The northern-most locality: Amami-Ôsima (MITSUKURI, 1912) (TK. No. 45).
20. *Actinopyga mauritiana* (QUOY & GAIMARD) Takarazima. The northern-most locality: Okinawa (MITSUKURI, 1912) (TK. No. 46–47).
21. *Stichopus horrens* SELENKA The shape and distribution of ossicles are quite the same as in previous descriptions, although besides ossicles numerous granules are found in the present specimen. Takarazima. Dist.: Torres Strait (CLARK, 1921) (TK. Nos. 48–49).

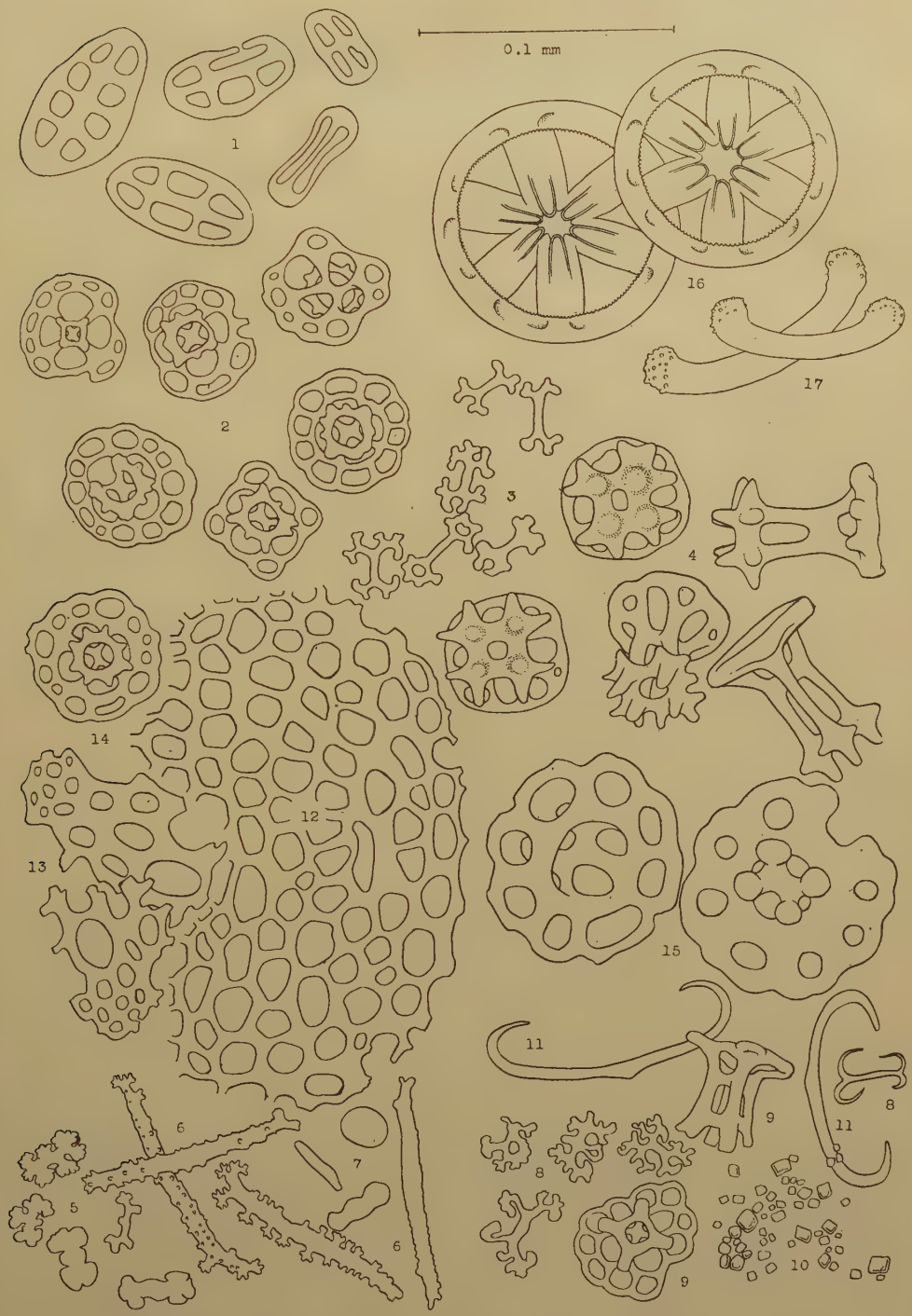
Fig. 3. Schema showing the posture of *Phyllophorus fragilis* MITSUKURI & OHSHIMA in sand.

22. *Pseudocucumis* sp. Takarazima and Nakanosima, in the latter it was rather common. (TK. Nos. 50–51).
23. *Phyllophorus fragilis* MITSUKURI & OHSHIMA Nakanosima. Buried in the sandy heaps on the reef. The animal adheres to the substratum by a part of the body near the anterior end and keeps in the sand a posture like U as indicated schematically in Fig. 3. When the animal is disturbed, it immediately jets the water from the anus and eviscerates soon after. The gonad is bluish green in male and fleshy yellow in female. Dist.: Okinawa (OHSHIMA, 1912) (TK. No. 52).
24. *Polycheira rufescens* (BRANDT) Common in both Takarazima and Nakanosima. The northern-most locality: Misaki. (TK. Nos. 53–54).

EXPLANATION OF PLATE VII

(Ossicles of holothurians collected from the Tokara Islands)

Fig. 1. *Holothuria* (*Holothuria*) *vagabunda* SELENKA, buttons.
Fig. 2. „ „ „ „ , tables.
Fig. 3. *Holothuria* (*Holothuria*) *atra* JAEGER, rosettes.
Fig. 4. „ „ „ „ , tables.
Fig. 5. *Actinopyga mauritiana* (QUOY & GAIMARD), rosettes.
Fig. 6. „ „ „ , rods.
Fig. 7. „ „ „ , simple ossicles.
Fig. 8. *Stichopus horrens* SELENKA, rosettes.
Fig. 9. „ „ „ , tables.
Fig. 10. „ „ „ , granules.
Fig. 11. „ „ „ , hamate ossicles.
Fig. 12. *Pseudocucumis* sp., a part of basal plate.
Fig. 13. „ „ , fenestrate ossicles.
Fig. 14. „ „ , a table.
Fig. 15. *Phyllophorus fragilis* MITSUKURI & OHSHIMA, tables.
Fig. 16. *Polycheira rufescens* (BRANDT), wheels.
Fig. 17. „ „ „ , rods.



T. Tokioka: Invertebrate Fauna of The Tokara Islands, V.

INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

VI. ALCYONARIA[1)2)]

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With Plate VIII and 5 Text-figures

A small collection of Alcyonaria which Dr. T. Tokioka brought home from the Tokara Islands comprises only 8 species, including a species of *Microspicularia* apparently new to science. All these species, except a new one, are widespread throughout the warm Indo-West Pacific area, but have not been previously recorded from the southern territories of Japan. The materials were collected by Dr. Tokioka along the coast of two islands Nakano-sima and Takara-zima in the Tokara group at low tide, and no gorgonarian was included in the collection. Yet this collection is enough to provide an evidence speak for the subtropical feature of the fauna of the islands.

Stolonifera

Family Clavulariidae Hickson

1. *Clavularia inflata* Schenk

(Figs. 1, 2; Pl. VIII, Figs. 1, 2)

Clavularia inflata Schenk, 1896, p. 48, pl. III, figs. 24-26.
Clavularia inflata var. *luzoniana* May, 1900, p. 44, pl. I, fig. 4 & pl. V, fig. 1a, b.
Hicksonia köllikeri Dean, 1927, p. 115; Thomson & Dean, 1931, p. 15, pl. XII, figs. 4-6 & pl. XXII, fig. 9.
Clavularia inflata var. *luzoniana* Roxas, 1933a, p. 58; Macfadyen, 1936, p. 24.

Jap. Name. Tutu-umizuta (nom. nov.).

Material. Numerous colonies from Nakano-sima, at low tide (TK. Nos. 55–56).[3)]

1) Scientific Survey of the Tokara Islands, Report No. 7.
2) Contributions from the Seto Marine Biological Laboratory, No. 213.
3) Registered number of the Tokara collections deposited in the museum of the Seto Marine Biological Laboratory.

This clavulariid, together with the type species *C. viridis* Q. et G., have been fully described by the authors cited above. But for future reference some descriptions and illustrations of the present material may be given here supplementing those of previous authors mainly in regard to the spiculation and tentacle armature.

Numerous thickly-set polyps arising from a rather hard creeping stolon or plate-like base contain all stages of development. The majority of polyps show on the average 15 mm long, with a diameter of 2–3 mm at base and 4–5 mm at the swollen upper portion; in the largest one, the anthostele measures 20 mm long, 2.5 mm across at base and 6 mm across at top, and the flexible anthocodia which is contracted is 5–6 mm long, including tentacles. A smallest one, which is a pear-shaped bud, is only 5 mm long and 4 mm wide at base.

Fully developed tentacles, when extended, are about 5 mm long and bear innummerable pinnules wholly covering the oral surface. In younger polyps less than 5 mm in total height, however, the tentacles are 2–2.5 mm long and bear two or three rows of pinnules on each side, with a slight bare streak between them, about 11 to 14 in a row (Fig. 1*b*, *c*); larger tentacles seem to bear 4 rows on each side, at least in the middle.

The spiculation of the polyp varies very markedly in different parts, as shown in Fig. 1*a*. Pinnules are wholly covered with the minute rodlets, extending to the base around the margin of tentacle on the aboral surface, not towards the oral surface. The median line of the aboral surface of tentacle is beset with longitudinally disposed, smooth or slightly warted rods or spindles larger than the preceding. At the base of tentacles, slender narrow spindles are arranged in regular 8 chevrons; between them there is no spicule. The introvertible neck portion of the anthocodia is thin-walled, semi-transparent and bears a few small spindles arranged horizontally. The stomodaeum is also provided with slender rodlets in the lower portion alone. The anthostele and stolon are quite firm, thickly covered with stouter large spindles and derivatives.

The measurements of these spicules in millimeters are as follows:—

(1) Pinnule.....very minute finger-biscuit-like discs (Fig. 2*d–e*).
0.028×0.01; 0.03×0.014; 0.04×0.02.

(2) Base of pinnule around the margin of tentacle.....minute rodlets (Fig. 2*a–c*).
0.04×0.01; 0.07×0.017.

(3) Aboral side of tentacle axis.....slightly roughened rodlets or small spindles (Fig. 2*f–h*).
0.3×0.04; 0.4×0.05; 0.5×0.09.

(4) Lower portion of stomodaeal wall.....slender rodlets (Fig. 2*i–l*).
0.06×0.008; 0.085×0.02; 0.16×0.03.

(5) Crown of anthocodia.....slender, smooth or warty spindles; bifurcate at one or

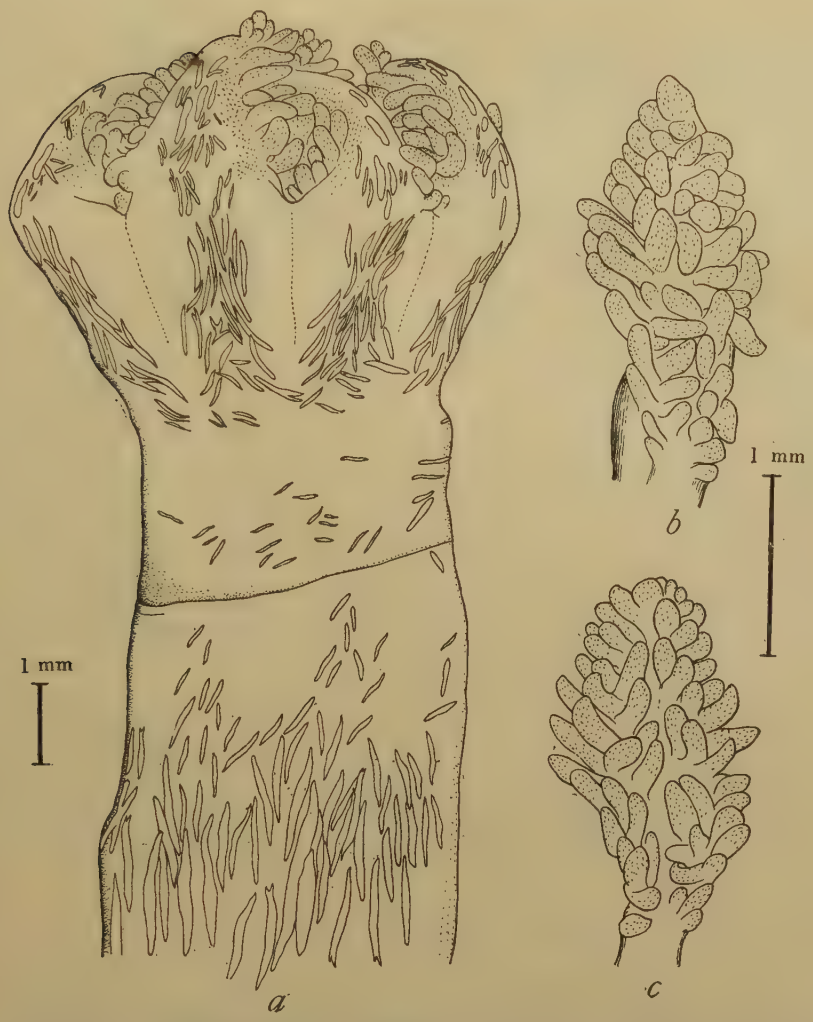

Fig. 1. *Clavularia inflata* SCHENK. *a*, Upper part of a polyp; *b*, *c*, inner view of tentacle in young polyps.

both ends, or with 3 or 4 branches (Fig. 2*m–p*).

0.7×0.07; 0.8×0.07; 0.9×0.07.

(6) Retrovertible neck portion of anthocodia.....slender, smooth or slightly warty spindles.

0.4×0.04; 0.6×0.07.

(7) Anthostele.....straight or slightly curved, large spindles with simple or compound warts; sometimes bifurcate at ends, or crosses (Fig. 2*q*).

0.4×0.07; 1.0×0.15, 1.35×0.15; 1.45×0.18.

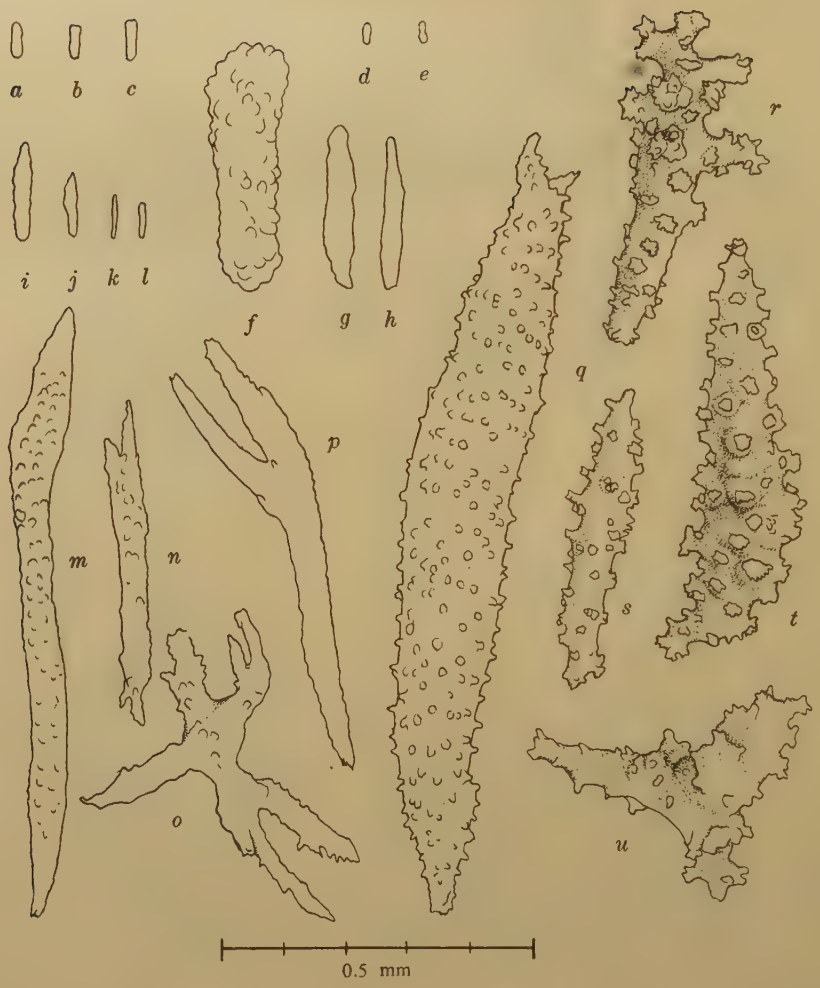

Fig. 2. Spicules of *Clavularia inflata* SCHENK. *a-c*, Spicules from base of pinnules on the aboral side of tentacle; *d-e*, from pinnules; *f-h*, from tentacle axis on the aboral side; *i-l*, from stomodaeal wall; *m-p*, from anthocodia; *q*, from anthostele; *r-u*, from stolon.

(8) Stolon.....short, plump spindles, triradiates or their derivatives, covered with high compound warts (Fig. 2*r–u*).

0.38×0.09; 0.6×0.09; 0.7×0.16; 0.8×0.18.

Retractile anthocodia and tentacles are creamy white or light grey; in the living state any greenish tint is not observed. Upper portion of anthostele with sparsely set spicules is light grey, while its lower portion and stolon dirty brown. In some of the polyps, the coloration is not so distinctly differentiated.

Distribution. Luzon (Philippines), Ternate, Indonesia, Low Isles (Great Barrier

Reef) and southern end of Formosa (unpublished).

Remarks. The Tokara specimens agree in detail with the Luzon specimens first described by MAY (1900) as a variety of *C. inflata* from Ternate. This variety should be included in the type species, since the specimens described by SCHENK may be indeed a young form, as inferred from his descriptions and figures. The generic name *Hicksonia* should be discarded according to the laws of priority, as pointed out by MOLANDER (1929) and ROXAS (1933 a), although GOHAR (1940) emphasizes to retain the name as a unique group showing a close affinity with *Tubipora*. I can not share his opinion that "*Hicksonia*" (*viridis* and *inflata*) and *Pachyclavularia* (*erecta* etc.) are far apart from the ordinary clavulariid type in the presence of connecting tubes between the polyps.

As THOMSON and DEAN (1931) state, many of the polyps arise from the complicated, irregularly branched stolon which forms a network in different planes. This is apparently due to the unevenness of the surface of the substratum which is sand-grains deposited on the rock or a mass of sand-forming nests of a certain sedentary polychaete. Therefore, some of the stolons from which is borne a new polyp-bud, become to extend enough to touch the body wall of the adjoining polyp at various levels; its end is finally joined together with the latter but exists no organic connection between the polyps. As far as my observation goes, there is no evidence to show an actual intrusion of the internal canals of the stolon into the coelenteric cavity of the joined polyp (see also HICKSON, 1886, p. 323 and 1930, p. 242). Anyhow, the stolon connecting one polyp with the middle of another, as seen in this species and *C. viridis*, is not essentially different from that in other ordinary stoloniferans.

ALCYONACEA

Family Alcyoniidae VERRILL

2. *Sarcophyton acutangulum* (MARENZELLER)

(Fig. 3 *a–d*; Pl. VIII, Fig. 3)

For synonymy see KÜKENTHAL, 1910, p. 25; TIXIER-DURIVAULT, 1946, p. 81.

Jap. Name. Umitake (nom. nov.).

Material. One specimen from Nakano-sima, at low tide (TK. No. 57).

The speciman is small, showing a total height of 5 cm of which 4 cm is the stalk. The colony is quite mushroom-shaped, with a disc slightly folded at the margin and hollowed in the center, about 0.3×0.4 cm in diamater. Some of the autozooids, mainly in the central portion, are fully expanded up to 1 mm in length. These are 0.5 mm apart and there is only one row of siphonozooids between two autozooids. The spicules

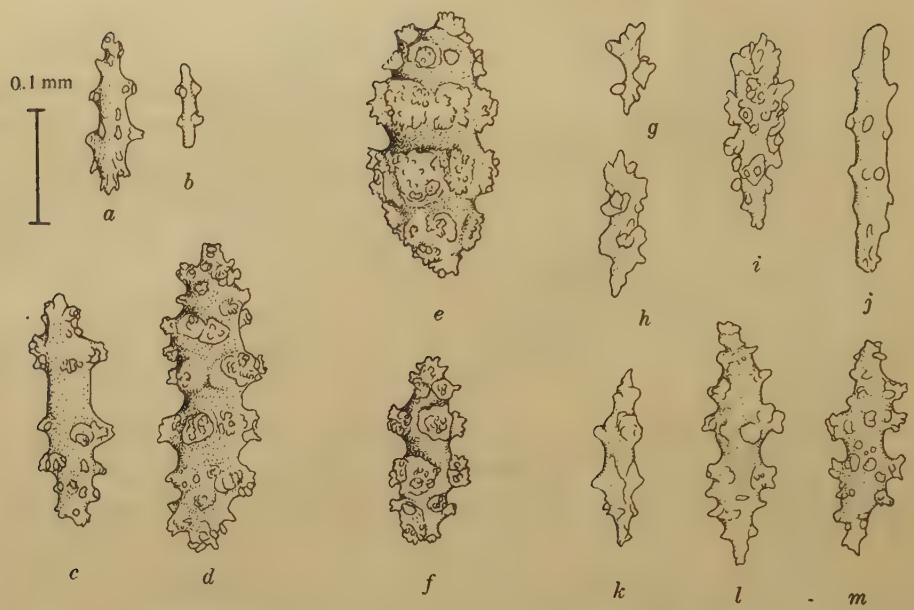

Fig. 3. Spicules of *Sarcophyton acutangulum* (MARENZELLER) (*a-d*), *S. trocheliophorum* MARENZELLER (*e, f*) and *S. moseri* ROXAS (*g-m*). *g-j*, from disc interior and the rest from stalk interior.

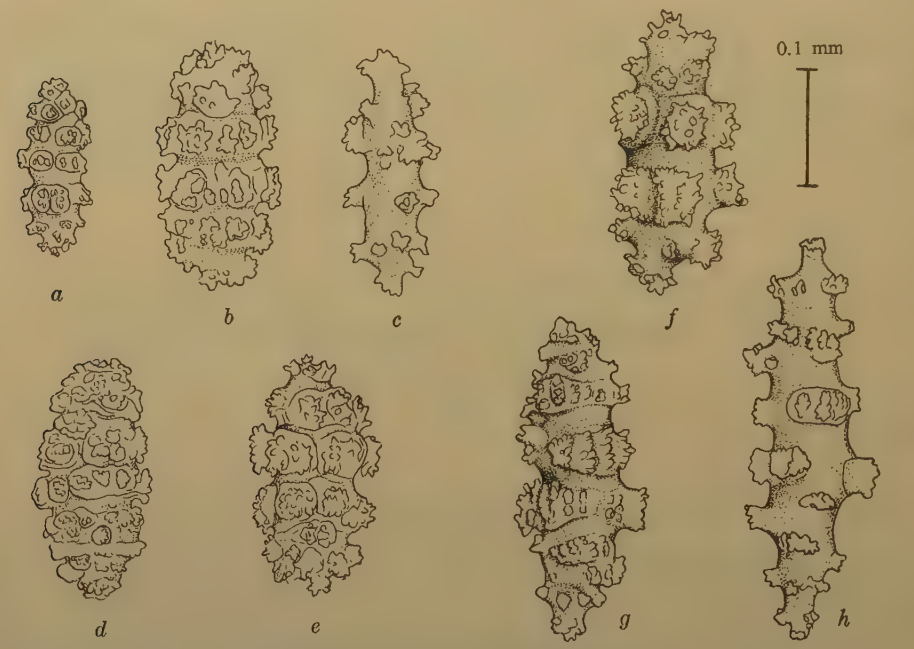

Fig. 4. Spicules of *Lobophytum pauciflorum* (EHRENBERG) (*a-e*) and *L. crebriplicatum* MARENZELLER (*f-h*). *a*, Spicules from disc cortex; *b*, *c*, from stalk cortex; *d*, from disc coenenchyme; *e-g*, from stalk coenenchyme; *h*, from disc coenenchyme.

of stalk interior are warty spindles, covered with 2–6 whorls of compound warts, the number of which increases in larger spicules.

Distribution. Red Sea, Ceylon, Maldives, north and southwest Australia, Tonga, Fiji Islands, Indonesia.

The distribution of this species further extends as far north as the Kii coast of middle Jappan, as occasionally found there.

3. *Sarcophyton trocheliophorum* MARENZELLER

(Fig. 3 *e–f*; Pl. VIII, Fig. 4)

For synonymy see KÜKENTHAL, 1910, p. 18; TIXIER-DURIVAULT, 1946, p. 349.

Jap. Name. Hidaberi-umitake (nom. nov.).

Material. Two specimens from Nakano-sima, at low tide (TK. No. 58).

Two subequal colonies, greenish-brown in colour, have the disc much convoluted at the margin into about 10 main thick folds, the largest one measures a disc 67 mm in maximum diameter and a stalk 30 mm high on one side and 55 mm in maximum diameter. Between two autozooids about 0.8 mm apart, about 2 or 3 tiny siphonozooids are found; yet more numerous may be found in larger colonies. There are up to 15 autozooids to a centimeter at the margin. The spicules of the stalk are mostly round-ended, barrel-shaped one, with 2 broad median whorls and 2 terminal clusters of very large compound warts, on the average 0.24×0.1 mm in size.

Distribution. Widespread in the warm Indo-West Pacific area.

4. *Sarcophyton moseri* ROXAS

(Fig. 3 *g–m*; Pl. VIII, Fig. 5)

Sarcophyton moseri ROXAS, 1932, p. 80, pl. I, fig. 2a-e; ROXAS, 1933b, p. 378, pl. I, fig. 6.
Sarcophytum moseri TIXIER-DURIVAULT, 1946, p. 169.

Jap. Name. Usuberi-umitake (nom. nov.).

Material. One specimen from Nakano-sima, at low tide (TK. No. 59).

The specimen agrees well with the Philippine specimen of this species. The disc, about 57×70 mm, slightly projects from the stalk, with about 7 low main folds around the broadly depressed central portion. The stalk is rather short and broad, being about 30 mm high and 53 mm wide at base. The folded rim of the disc is rather thin, about 4 mm in thickness everywhere. There is only one row of siphonozooids between two autozooids, less than 0.5 mm apart. The spicules of the disc surface are small rods or clubs with irregularly placed simple warts and 0.08–0.2 mm long. In the stalk interior are small spindles with small irregularly placed warts and pointed at both ends, about

0.15–0.2 mm long. Greenish cream in colour.

Distribution. Mindoro (Philippines), Détroit de la Sonde.

5. *Lobophytum pauciflorum* (EHRENBERG)

(Fig. 4 *a–e*; Pl. VIII, Fig. 6)

Lobularia pauciflora EHRENBERG, 1834, p. 58.
Sarcophytum pauciflorum KLUNZINGER, 1877, p. 29, pl. II, fig. 2.
Lobophytum pauciflorum var. *validum* MARENZELLER, 1886, p. 366, pl. IX, fig. 12; MOSER, 1919, p. 92, fig. 20; MACFADYEN, 1936, p. 48.
Lobophytum pauciflorum HICKSON & HILES, 1900, p. 505; MOSER, 1919, p. 86, fig. 19, pl. V, figs. 3-6; THOMSON & DEAN, 1931, p. 69; ROXAS, 1933b, p. 367; MACFADYEN, 1936, p. 47, pl. III, fig. 1.
Lobophytum candelabrum ROULE, 1908, p. 177; THOMSON & DEAN, 1931, p. 65.

Jap. Name. Ibo-unetake (nom. nov.).

Material. Two fragments of colonies from Takara-zima, at low tide (TK. No. 60).

Both colonies, about 11 cm in maximum diameter, agree well with MARENZELLER's var. *validum*. But as suggested by ROXAS, this may be merely a developmental variety. The colony is carpet-like, with a sterile stalk broader than high; the texture is very firm and the colour is uniformly dark grey. The disc, which is sharply defined from the sterile stalk, bears a lot of high finger-like lobes all over the surface, forming somewhat parallel rows. These lobes are upright and roundly tipped, on the average 6 mm thick and 10–12 mm high; some low secondary lobes occur on the slightly ridged margin. The autozooids are distinct, about 2 mm apart on the lobes, but rather scarce towards the disc between lobes. The siphonozooids are smaller but visible, about five between two autozooids on the lobes.

The cortical spicules of the lobes are mostly small spindles, about 0.08×0.02 mm to 0.2×0.07 mm. Those in the sterile stalk include larger, blunt-ended, barrel-like spicules, about 0.18×0.08 mm to 0.23×0.09 mm and slender spindles, about 0.14×0.05 mm to 0.22×0.07 mm. In the coenenchyme of lobes and stalk are mostly barrel-shaped spicules with usually 4 to 6 distinct whorls of heavy warts; they measure 0.18×0.09, 0.2×0.1, 0.23×0.09, 0.24×0.09 in millimeters. In larger barrels, the space between warty whorls are usually narrow, and in smaller and longer spindles are warts often in whorls or irregularly scattered.

Distribution. Widespread in the warm Indo-West Pacific area.

6. *Lobophytum crebriplicatum* MARENZELLER

(Fig. 4 *f–h*; Pl. VIII, Fig. 7)

Lobophytum crebriplicatum MARENZELLER, 1886, p. 362, pl. IX, fig. 7; MOSER, 1919, p. 79,

fig. 15; ROXAS, 1933b, p. 362; MACFADYEN, 1936, p. 45.

Jap. Name. Naga-unetake (nom. nov.).

Material. Two specimens from Nakano-sima, at low tide (TK. No. 61).

A large incomplete colony, with a total height of 7.5 cm and a capitulum of 7×9 cm in diameter, only half of which remains. The capitular disc hollowed in the center, is covered with high, leaf-like folds, about 5 mm thick and about 15 mm high, whose apices are generally smooth but often slightly notched one or two times, though not deeply cleft. These folds extend radially towards the center where is not folded; the longest one extends up to 6 cm. The wall of the stalk is for the most part creamy grey coloured and longitudinally striated, but transversely corrugated near the base where it is brownish.

The autozooids are large, 1–2 mm apart and between these lie the closely set siphonozooids, about 1 or 2 between two autozooids on the lobes, but 2 or 3 on the sides. The spicules of the stalk interior are spindles with broad compound warts in more than 4 whorls, up to 0.25–0.29 mm long and 0.075 mm wide. Those in the disc interior are as a whole longer spindles with small compound warts, up to 0.35 mm long and 0.07–0.08 mm wide. Compared with those in the preceding species, the spicules are longer and more slender, with widely spaced warts, not forming so distinct whorls. Another smaller colony, about 3 cm high and 5.5 cm in longest diameter (Pl. VIII, Fig. 7), shows the same appearance and spiculation, though the colouration is lighter.

Distribution. Tonga Island, Low Isles and Madagascar (after MOLANDER, 1921).

7. *Microspicularia sphaeroides* n. sp.

(Fig. 5; Pl. VIII, Figs. 8–10)

Jap. Name. Nôtosaka (nom. nov.).

Material. Holotype (S. M. B. L. No. 126) and 5 paratypes (TK. No. 62) from Takara-zima, at low tide.

These six colonies with a cerebriform appearance clearly belong to the genus *Microspicularia*, but cannot be referred to any of the described species. Recently, TIXIER-DURIVAULT (1943–44, 1948) has comprehensively studied the encrusting *Alcyonium*-like group with small capstan-like and more tiny disc-shaped sclerites, which has been confused with the typical *Alcyonium*. Unfortunately, for this group she revived the old name *Lobularia* which had already been abandoned as a synonym of *Alcyonium* (the type of LAMARCK, *L. digitata*, is a species of the typical *Alcyonium*), despite that a revised opinion on the nomenclature was expressed by MACFADYEN (1936) after her Siboga report. Hence I am now using the name *Microspicularia* of MACFADYEN instead of *Lobularia*.

All the colonies are rather small, roughly round to oval in outline, up to 45 mm

in maximum diameter, and covered wholly with 10–15 compressed round lobes which are from 5 mm to 7 mm high and from about 4 mm to 7 mm wide; some of the lobes are not distinctly divided but become lengthened with 2 or 3 slight notches at the apex. The sterile stalk attached to the dead coral block is not wider than the capitulum, and is delimited by the broadening of marginal lobes from the latter; its height is only 5 mm anywhere.

The polyps are small, 0.7–0.9 mm in diameter, closely set and count about 7 to a length of 5 mm. These are completely retractile, but some of them especially on

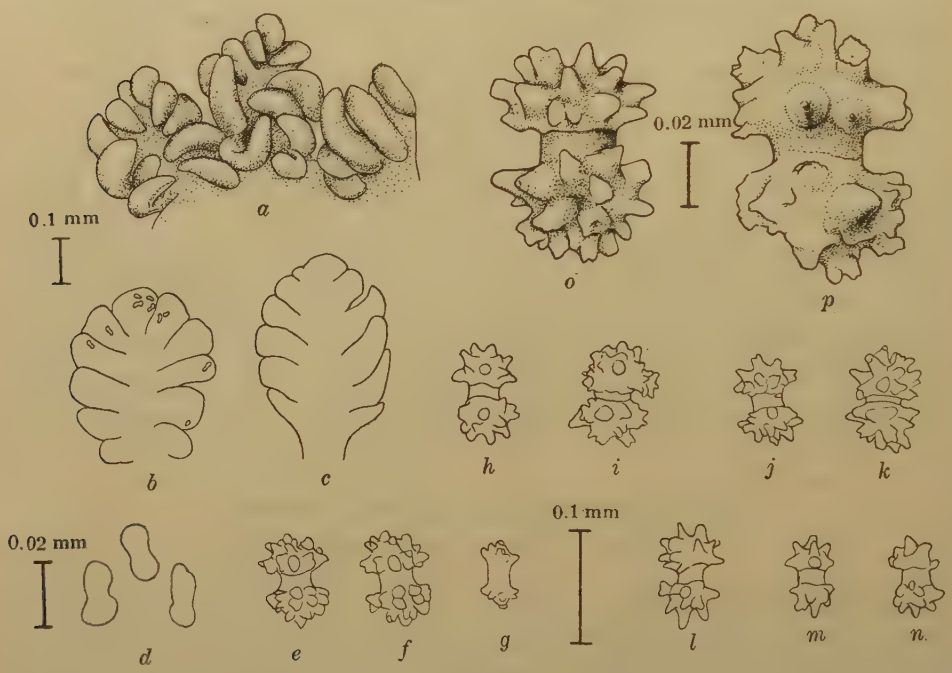

Fig. 5. Tentacles and spicules of *Microspicularis sphaeroides* n. sp. *a*, Aboral view of three tentacles; *b*, *c*, tentacle; *d*, spicules from pinnules; *e-g*, from cortex of lobes; *h-i*, from cortex of base; *j-k*, from coenenchyme of base; *l-n*, from coenenchyme of lobes; *o*, from coenenchyme of base, much enlarged; *p*, from cortex of lobes, much enlarged.

the valleys remain fully expanded. The tentacles, about 0.3 mm long, bear five broad pinnules on each side; most of them are apparently devoid of spicules, but a few very minute spicules may be found only at the ends of pinnules; these spicules are finger-biscuit-shaped, reaching 0.018×0.008 mm in size. All the spicules contained in the cortex and coenenchyme are almost similar to one another in shape as well as in size. They are all capstans with roundly pointed warts at both ends and a median narrow waist, which are as a whole much smaller than those found in other species,

as follows:

Cortical spicules of lobes·····0.05×0.04 mm; 0.07×0.04 mm.
Coenenchymal spicules of lobes·····0.05×0.04 mm; 0.07×0.04 mm.
Cortical spicules of base ·····0.07×0.04 mm; 0.08×0.05 mm.
Coenenchymal spicules of base ·····0.08×0.05 mm; 0.085×0.05 mm.

No finger-biscuit-like forms do exist in the tissue excepting tentacles.

The colonies in spirit are uniformly greyish white. According to Dr. TOKIOKA's field-note, their expanded colonies under the water are brownish, but change suddenly to white when exposed.

Remarks. This species at a glance resembles closely *M. sphaerophora* (EHRENBERG) amongst all of the described species, but it is distinguishable from the latter in the smallness and uniformity of all spicules and in the polyps almost devoid of spicules.

COENOTHECALIA

Family Helioporidae MOSELEY

8. *Heliopora coerulea* (PALLAS)

Heliopora coerulea EGUCHI, 1948, p. 362, pl. 60, figs. 3, 4, 6 (with synonymy).

Jap. Name. Aosango.

Material. A dead fragment of this blue coral (TK. No. 63) was found as mingled with coral blocks and sands at Nakano-sima. This species is known to occur in the Ryukyu Islands in both the recent and fossil forms, as far south as the South Sea Islands and the Indian Ocean, where it is very plentiful in coral reefs. But Dr. TOKIOKA did not find it there in the living state.

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EXPLANATION OF PLATE VIII

(All the photographs taken in spirit by the aid of Mr. I. YAMAZI.)

Figs. 1, 2. *Clavularia inflata* SCHENK. Nakano-sima.

Fig. 3. *Sarcophyton acutangulum* (MARENZELLER). Nakano-sima.

Fig. 4. *Sarcophyton trocheliophorum* MARENZELLER. Nakano-sima.

Fig. 5. *Sarcophyton moseri* ROXAS. Nakano-sima.

Fig. 6. *Lobophytum pauciflorum* (EHRENBERG). Takara-zima.

Fig. 7. *Lobophytum crebriplicatum* MARENZELLER. Nakano-sima.

Fig. 8. *Microspicularia sphaeroides* n. sp. Takara-zima. (Holotype)

Figs. 9, 10. *Microspicularia sphaeroides* n. sp. Takara-zima. (Paratypes)

(Figs. 1, 2, 8–10, ×1; Figs. 3–6, ×2/3)

H. Utinomi : Invertebrate Fauna of The Tokara Islands, VI.

STUDIES ON THE EGGS AND LARVAE OF THE JAPANESE GASTROPODS (4)*

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With 3 Text-figures

The writer published in 1944 three papers on the eggs and larvae of some Japanese gastropods in "the Japanese Journal of Malacology" (Venus), Vol. 13. The present report deals with *Serpulorbis imbricata*, *Brochina glabella*, *Amalthea conica*, *Amalthea* (*Antisabia*) *foliacea*, *Crepidula gravispinosa* and *Rosenia castanea*.

I express here my hearty thanks to Dr. Taku KOMAI for his kind guidance and incessant encouragement during the course of this study.

Serpulorbis imbricata (DUNKER)

(Figs. 1, a–h)

The species is very common on rocks between tidal marks on the beach near the Seto Marine Biological Laboratory. The breeding takes place in May and June. The egg capsule (Figs. 1–3) is ovate, numbering from 20 to 30 in each mass which is attached to the inside of the tube of the shell at its attenuated extremity by a short peduncle; it measures 3 to 3.5 mm in length and 1.1 to 1.5 mm in breadth. The capsular wall is thin and transparent, so that the eggs are clearly seen through. The eggs are cream yellow, spherical and 0.24 mm in diameter. Each capsule contains 70–80 eggs (Fig. 1c) of which some develop into veliger larvae eating the rest of eggs. The veliger (Fig. 1f) is about 0.4 mm long and bears a shell around the posterior part of the body and a bilobed ciliated velum on the anterior end. The velum is provided with a pair of minute tentacles. Each tentacle has a minute eye spot at the swollen base. The foot is small and triangular, and has an otocyst at the base. The whorl of the shell increases with development. In the veliger (Figs. 1e, g) of 0.44 mm in shell length, the shell is pale yellow and consists of two distinct whorls and has a

* Contributions from the Seto Marine Biological Laboratory, No. 214.

narrow umbilicus. The shell axis is tinted pale orange. The lobes have attained a large size, slightly constricted in the middle and with long cilia bordering them. The tentacles also have become prominent. The liver is orange or browish orange in colour, visible through the translucent shell. The mouth part and foot are purplish. The foot

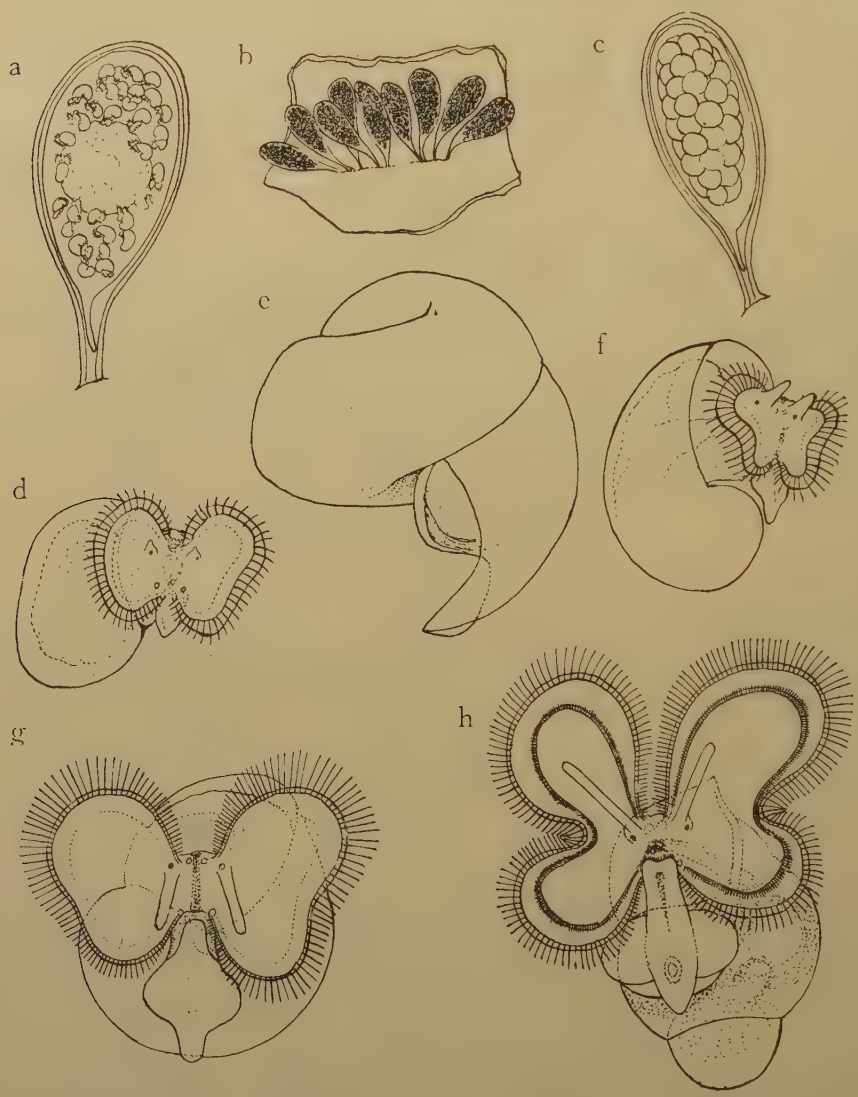

Fig. 1. *Serpulorbis imbricata* (DUNKER). *a*, egg capsule, containing veligers and a nurse mass; *b*, egg capsules adhered to the inside of shell of the parent; *c*, egg capsule containing eggs; *d*, veliger, 0.32 mm across; *e*, larval shell, 0.44 mm across; *f*, veliger, 0.42 mm in shell length; *g*, veliger, 0.44 mm in shell length; *h*, veliger, 0.63 mm in shell length.

is produced laterally into two processes and carries a small and thin operculum. In the stage when the shell measures 0.63 mm in length and 0.45 mm in breadth, the veliger (Fig. 1h) hatches out. The larva has the umbilicated shell with 3½ whorls and four lobed velum bordered by long cilia. The upper lobes are larger than the lower. The foot has considerably developed, and bears the thin operculum on the back.

Brochina glabella A. ADAMS

(Figs. 2, a–d)

The creeping larva (Figs. 2, a, b) measures 0.58–0.6 mm in shell length and has a spiral embryonic shell with about 1½ whorls. The last body whorl is uncoiled and detached from the penultimate one. The spiral part of the shell is smooth, while the uncoiled part is faintly marked with growth lines. The bilobed velum on the lateral sides of the head has been reduced. The shell (Fig. 2c), 0.9 mm in length, still retains the posterior spiral part. This part is empty, however and the animal occupies only the anterior straight part; there is a distict septum between the two parts. When the shell (Fig. 2d) becomes more than 1 mm in length, the spiral part of shell has been detached, and the animal completes metamorphosis.

This small snail with a tubular shell is common under stones between the tidal marks near Shirahama, Wakayama Pref.

Amalthea conica (SCHUMACHER)

(Figs. 2, e–j)

The eggs and larvae of this species have been described and figured by S. SUZUKI (1935) as of *Hipponyx pilosus*. This species is very common on the shell of some gastropods such as *Haliotis* and *Astraea*.

The adult spawns in spring and summer. The egg capsule (Fig. 2c) is ovate and attached to the substratum by a short stalk, and covered by the parent. Three to six egg capsules are united by the stalk into a common stem. Each capsule contains about 30 eggs which are yellowish white and 0.45 mm in diameter. Besides the eggs many yolk fragments are observed in the capsule. These may be a kind of nurse materials. The larva, 0.58 mm long (Figs. 2f, g), is ovate, rounded anteriorly, attenuated posteriorly and has a small circular velum bordered by long cilia, and provided with eye spots; a small triangular spot is also present. The shell is thin, cup-like, and covers the posterior part of this veliger. In the post veliger stage, the shell (Figs. 2h, i) is brownish and has 1½ whorls, marked with about twenty ciliated radial threads. The velum is bilobed; the tentacles are long and with eyes at the base. The foot is well developed, purplish in colour, and carries an operculum on the

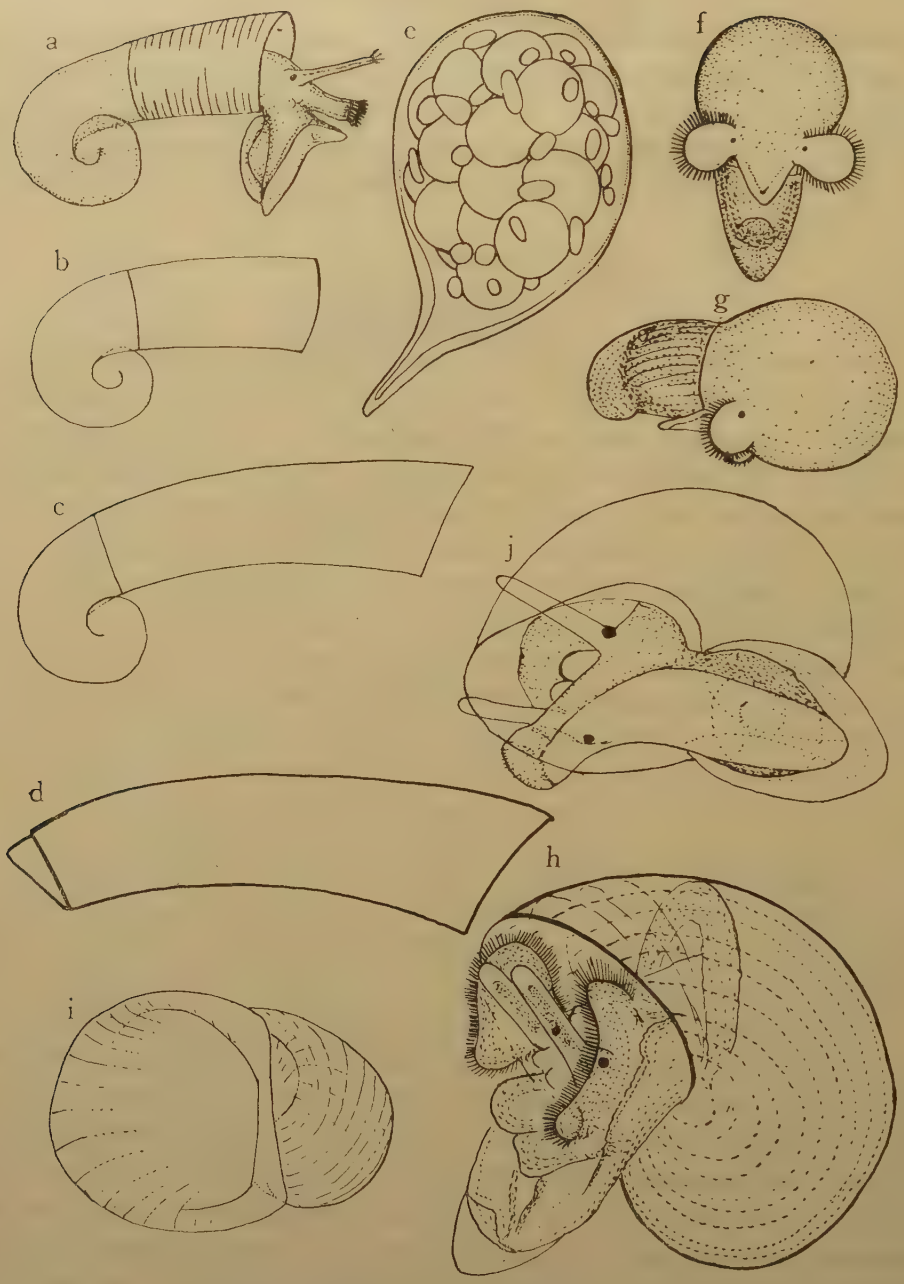

Fig. 2. *Brochina glabella* A. ADAMS (*a-d*),
Amalthea conica (SCHUMACHER) (*e-j*).
a, young creeping animal; *b*, young shell, 0.6 mm in length, still retaining the embryonic shell; *c*, young shell, 0.9 mm in length; *d*, immature shell, 1.5 mm in length; *e*, egg capsule, containing eggs and yolk fragments; *f*, *g*, veliger, 0.58 mm across; *h*, *i*, veliger; *j*, young creeping larva.

dorsal side. The newly hatched larva (Fig. 2j) acquires a radula in the mouth, and has lost the operculum before long.

Amalthea (*Antisabia*) *foliacea* (QUOY et GAIMARD)

(Figs. 3, a–b)

This species is very common in crevices of rocks between the tidal marks near Shirahama. Breeding takes place in summer, from June to August. The egg capsule (Figs. 3a, b) is thin, transparent, ovate in shape, and 2.4 mm long; it is fixed to the substratum by its stalk which is 2.2 mm long, and covered by the parent. About 15 capsules are laid by one individual. Each capsule contains about 15 eggs, which are 0.3 mm in diameter and pale yellow. The embryo, 0.45 mm long, has cilia on the whole surface and a thin cup-shaped shell in the posterior part. The shell (Fig. 3c) is 0.42 mm long, thin, transparent, pale yellow in colour and has one-fourth whorl. The beginning whorl is smooth, and the remaining part has about twenty threads which are densely sprinkled with minute granules. The velum consists of two rounded lobes, bordered by long cilia. The tentacles are rather long and provided with eyes at the base. The foot is triangular, tapering posteriorly, and bears an operculum on the dorsal lobes of the foot. The full-grown veliger (Fig. 3d) has a shell about 0.5 mm in length. The shell consists of two whorls increasing rapidly in diameter. The growth lines on the surface are distinct. The animal is purplish in colour. The vela and tentacles are more enlarged. The operculum is still present.

Crepidula gravispinosa KURODA et HABE

(Figs. 3, e–i)

The species has been erroneously identified with *Crepidula aculeata* (GMELIN) of the Atlantic. It should be named *Crepidula gravispinosa* KURODA et HABE. The animal is common on rocks near the tidal marks at Shirahama.

Spawning takes place from May to November. The eggs are contained in fan-shaped capsules (Fig. 3e) are 1.5 mm across aud united in a branch by their stalks in a common stem fastened to the substratum. About five capsules make a cluster and are covered by the parent. The capsules are thin, transparent, and contain each from 15–20 eggs, which are 0.2 mm across and cream yellow in colour. The larval shell measures 0.4 mm in length and has 1½ whorls. With development the diameter of the whorl enlarges, and the sculpture with many ciliated threads becomes distinct. The bilobed velum is bordered by long cilia and provided with long tentacles bearing eyes near the base. The otocyst is also distinct. In the larva (Figs. 3, f–h) with the shell 0.72 mm long and of two whorls has the velum more enlarged. The thin

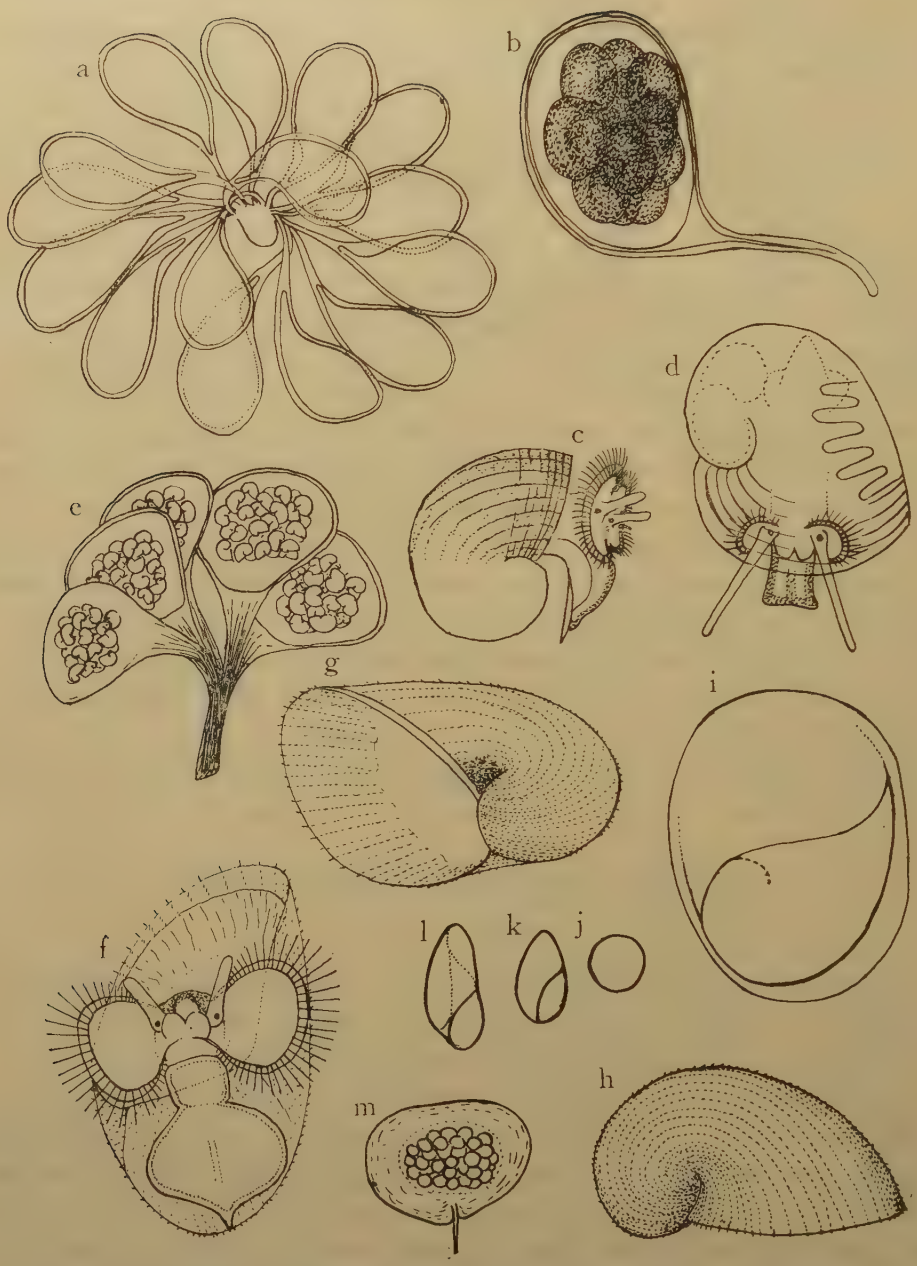

Fig. 3. *Amalthea* (*Antisabia*) *foliacea* (QUOY et GAIMARD) (*a-b*), *Crepidula gravispinosa* KURODA et HABE (*e-i*), *Rosenia castanea* (DALL) (*j-m*). *a*, a mass of egg capsules; *b*, egg capsule containing eggs; *c*, veliger, 0.42 mm in shell length; *d*, veliger, 0.5 mm in shell length; *e*, a mass of egg capsules; *f*, veliger, 0.72 mm in shell length; *g*, *h*, young shell, 0.72 mm in length; *i*, young creeping shell; *j*, egg, 0.11 mm across; *k*, embryonic shell, 0.19 mm in length; *l*, embryonic shell, 0.25 mm in length; *m*, egg capsule containing eggs.

operculum is still retained on the dorsal lobes of foot; the radula has developed in the mouth part. In the larva of 1.2 mm in shell-length, metamorphsis already takes place; the velum has reduced and the radula becomes distinct.

Rosenia castanea (DALL)

(Figs. 3, j–m)

On July 2, 1944, Mr. Masuoki HORIKOSI kindly sent the present specimens collected at Okitsu, Chiba Pref. and preserved in alcohol. One of the specimens had laid a mass of egg capsules among spines of *Pseudocentrotus depressus*. The egg capsules (Fig. 3m) measuring 1.2 mm in breadth and 1.0 mm in length are colourless, transparent, ovate, and attached to the spines of the host by the stalk. About fifty eggs were contained in the fluid within the capsule. The eggs (Fig. 3j) are spherical in shape, yellowish-white in colour and 0.11 mm across. The larvae (Figs. 3k, l) in the capsule had transparent brownish shell with $1\frac{1}{2}$ whorls, which is about 0.25 mm in length and 0.15 mm in breadth.

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NOTES ON THE TYPE SPECIMENS OF THREE SPECIES OF JAPANESE MOLLUSCS DESCRIBED BY F. JOUSSEAUME*

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Zoological Institute and Seto Marine Biological Laboratory,
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With Plate IX

Though three Japanese species had been described in the French journal "Le Naturaliste" by F. JOUSSEAUME in 1894 and 1899, their type specimens were not figured until to-day. Fortunately enough, Dr. Max DESJARDIN sent me the photographs of *Guildfordia yoka*, *Malvufundus irregularis* and *Pinna epica*, preserved in the Muséum National d'Histoire Naturelle de Paris, together with copies of their original descriptions. They are here published by the kind permission of the Director of the above Museum and Dr. M. DESJARDIN. As the above-mentioned journal is far from accessible in Japan, the redescriptions and illustrations of these original specimens may be useful to workers on the Mollusca.

Thanks are due to the Director of the Muséum National d'Histoire Naturelle de Paris and Dr. M. DESJARDIN for their kindest cooperation. Also I am grateful to Dr. Tokubei KURODA and Dr. Iwao Taki for their warm suggestions.

Malleus (*Parimalleus*) *irregularis* (JOUSSEAUME)

(Pl. IX, Figs. 3, 4)

1894 ***Malvufundus irregularis*** JOUSSEAUME, Le Naturaliste, (2) 8 (16), p. 228.

"Testa irregularis, depressa, fere ovalis, antice et postice inaequaliter biolata, corneo-cutea, maculis nigrescentis irregulariter aspersa, concentrice striata, versus apicem lamellis concentrice instructa, cauda curcata, ala longissima fisso a cauda disjuncto.

Dimensions ; haut., 30 millimétres ; larg., 52 millimétres ; épaiss., 7 millimétres.

Hab. : Japon."

The type specimen of this species is abnormal in shape, for the normal specimens from various localities from Japan are generally very large in height and very narrow

* Contributions from the Seto Marine Biological Laboratory, No. 215.

in breadth, lacking the winged processes at the extremities of hinge line. This is very common under stones and in their crevices between tidal marks on the Pacific coast of southern Japan.

Atrina (*Servatrina*) *epica* (JOUSSEAUME)

(Pl. IX, Figs. 1, 2)

1894 *Pinna epica* JOUSSEAUME, Le Naturaliste, (2) 8 (16), p. 229.
1953 *Atrina* (*Servatrina*) *epica* HABE, Illust. Cat. Jap. Shells, 24, p. 194, pl. 25, fig. 8.

"Testa subtrigono-ovalis, subventrosa, apice latissima hians 2/3 longitudinis superante, basi mucronato-acuta, fulvo grisea, inferne violaceo-nigra, transversim undulato-plicata et radiatim irregulariter costata, costis evanidis undulatis inaequaliter exsertis.

Dimensions; long., 156 millimétres; larg., 65 millimétres; épaiss., 27 millimétres.

Hab.: Japon."

Compared with my specimens at hand collected off Wakayama and Tosa Bay, Shikoku, the type specimen of this species is very large, but the surface sculpture of this specimen is poorly preserved, probably due to the long stay in the mud. In the perfect specimens, the surface is covered with longitudinally radiated narrow cords on which minute scales are arranged at the points of intersection of the growth lines, giving the surface a reticulated aspect. *Atrina tenuis* HABE from Tosa Bay resembles this pretty species, but the former is uniformly coloured light yellow and provided with distantly radiate narrow cords on which moderately large scales are set.

Guildfordia yoka JOUSSEAUME

(Pl. IX, Figs. 5, 6)

1899 *Guildfordia yoka* JOUSSEAUME, Le Naturaliste, (2) 13 (21), p. 48.
1908 *Guildfordia yoca* SCHEPMAN, Exped. Siboga, 49a, p. 26.

"Testa depresso-conica, supra purpureo-rufescens, inferius cinereo-alba, calloso-umbilicata, callositas margaritacea profunde excavata; anfr. 7, depressi, convexiusculi, circum sucturam seriebus granulis (7–8) dense ingulati, ad peripheriam radiatim rugoso-plicat, ultimus inferne convexus, striis radiatibus, falcatis et spiralibus minutissime decussatus; prope callositatem linea rosea circumcurrente pictus, spinis longissimis, subdistantibus radiatus; sutura impressa spinis obtectantibus interrupta; apertura oblique ovalis; labrum sinuatum margaritaceum.

Dimensions; Diam. maj. 53 millimétres; Min. 45 millimétres; Altitude: 27 millimétres.

Hab.: Japan."

This is a second species of *Guildfordia* which was established by GRAY 1850 for *Astralium triumphans* PHILIPPI. Though this type specimen is very large in size, the characteristic long spines on the periphery are entirely lost at the distal portion. The type specimen, however, agrees completely with the specimens before me which were collected from the deep bottom of Tosa Bay, Shikoku and off Wakayama Pref., Honshu. The locality of this type species was described only as Japan. Moreover, this species has been recorded from the East Indies in the molluscan reports of "Siboga Expeditie" by SCHEPMAN (1908) with some slight discrepancies from the Japanese specimens. This curious species differs from *G. triumphans*, which is widely distributed in East Indies, China and Japan, and is common off Minabe, Wakayama Pref,, Honshu, by very long spines at the periphery and absence of the beaded spiral cords on the base.

EXPLANATION OF PLATE IX

Figs. 1, 2. *Atrina* (*Servatrina*) *epica* (JOUSSEAUME).

Figs. 3, 4. *Malleus* (*Parimalleus*) *irregularis* (JOUSSEAUME).

Figs. 5, 6. *Guildfordia yoka* JOUSSEAUME.

T. Habe: Type Specimens of Molluscs Described by Jousseaume.

PLANKTON INVESTIGATION IN INLET WATERS ALONG THE COAST OF JAPAN

IX. THE PLANKTON OF ONAGAWA BAY ON THE EASTERN COAST OF TÔHOKU DISTRICT[1)]

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Seto Marine Biological Laboratory, Sirahama

With 10 Text-figures and 1 Table

On the eastern rias coast of the Tôhoku District, there are numerous indentations of different forms. For planktological investigation in these bays, my special attention was paid on the plankton communities in relation to the topographical conditions characterizing the rias coast and then the hydrological conditions in different bays. As a first step I surveyed Onagawa Bay, one of the remarkable bays on that coast, on August 28, 1951 on board the boat of the Onagawa Fisheries Laboratory, Tôhoku University.

The plankton samples were vertically collected from the 5 meter layer to the surface and from the bottom to the 5 meter layer by a KITAHARA's quantitative silk tow net in a small scale. The diameters of the mouth and largest part of the net are 11.25 cm and 25 cm respectively and the length is about 50 cm. Therefore, the net passes through the water of approximately 50 liters in every towing. The mesh of the MÜLLER's gauze is No. XX–13. Other methods of observations and examinations are referred to my previous papers in this series.

I am indebted to the staff members of the Onagawa Fisheries Laboratory and, in particular, Dr. C. MATSUDAIRA of Tôhoku University for his kind advice and aid on the determination of chlorinity and catalytic activity of sea water. Thanks are also due to Prof. D. MIYADI, Dr. H. UTINOMI and Dr. T. TOKIOKA for suggestion and advice. The investigation was partially supported by a grant from the Ministry of Education for scientific researches.

1) Contributions from the Seto Marine Biological Laboratory, No. 216.

Hydrological Conditions

Onagawa Bay (Fig. 1) lies on the base of Ozika Peninsula, forming a deep indentation of about 6.5 km long in the east and west direction. It communicates with the Pacific Ocean by a rather wide mouth of about 4 km, between the island of Izusima and the cape of Haya-saki. The coastal line is indented westwards to form two main inlets, Onagawa and Nonohama, and generally fringed with fantastic rock and stone, and sandy beaches are hardly developed. The basin is relatively deep. The greatest depth is found near the entrance, being about 4.5 km, and the 30 m isobath line runs deeply into both inlets along the coast line. Only a very small river pours into the head of the Onagawa inlet.

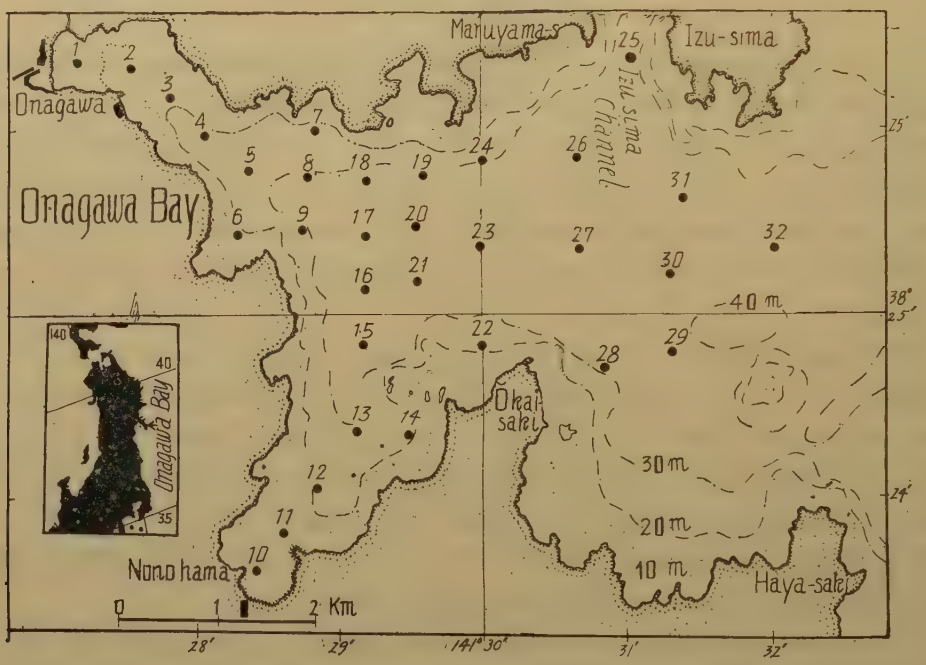

Fig. 1. Chart of Onagawa Bay showing stations and bathymetric contours.

The hydrological data from the analyses of surface samples are shown in Fig. 2.

Water temperature (Fig. 2, A): The water temperature at the superficial layer reaches its highest in the central area (about 25–25.3°C), and lowest in the innermost part of the Onagawa inlet (about 24–25°C).

Chlorinity (Fig. 2, C): Chlorinities at the surface were generally high. Lowest chlorinities were found at stations of the Onagawa inlet (about 18–18.5 Cl ‰), where pours a little fresh water from drainage. The Nonohama inlet showed the least

changes in chlorinity (about 18.5–18.7 Cl ‰), probably because of no drainage and the horizontal and vertical exchange with open sea water. In this area a patch of higher chlorinity than that of the outer region was found.

Transparency (Fig. 2, B): The transparency of water was the smallest in the Onagawa inlet and northern area of the central region (about 4–6 m). The water of the Nonohama inlet was more transparent (about 7–8.5 m) than that of the northern area of the bay. The highest area was found towards the eastern entrance. The

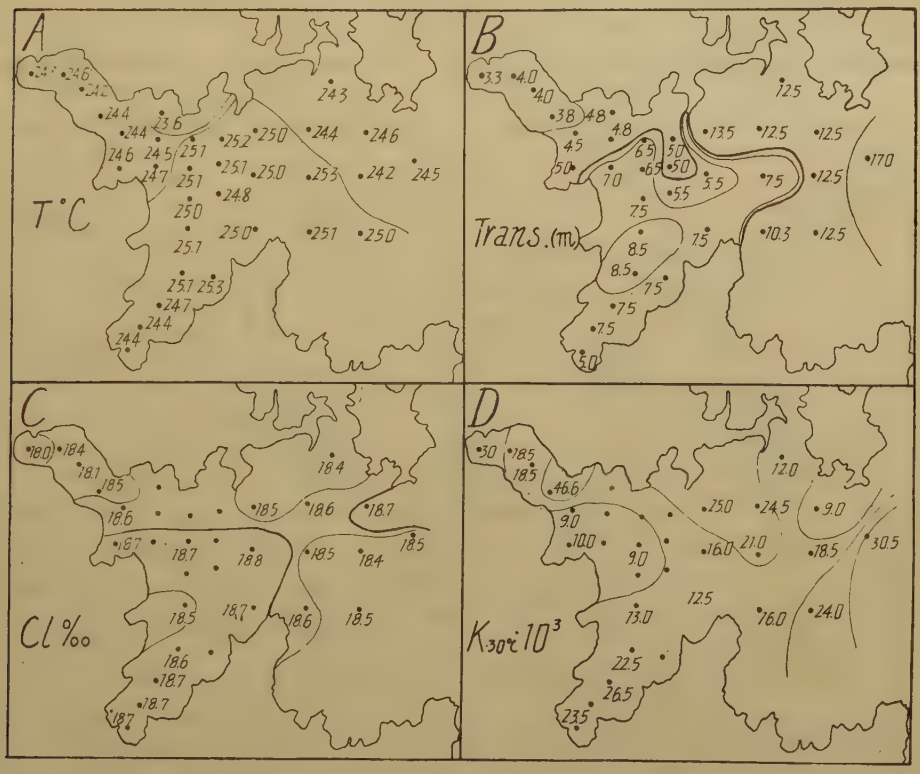

Fig. 2. Hydrological conditions during the survey (August 28, 1951).

A. Distribution of surface temperature in °C.
B. Distribution of transparency in M.
C. Distribution of chlorinity in ‰ of the superficial layer.
D. Catalytic activity of sea water in $K_{30°C}\cdot10^3$ of the superficial layer.

highest area was found towards the eastern entrance of the bay, measuring about 17 m near the south of Izusima.

Catalytic activity of sea water (Fig. 2, D): The highest value of the catalytic activity of sea water (MATSUDAIRA, 1950; YAMAZI, 1953) was found at the entrance of the bay and the Nonohama inlet (about 22–30 $K_{30°C}\cdot10^3$). The lowest value as

found at the mouth of the Onagawa inlet. At St. 1 and 4 in the Onagawa inlet, however, it showed locally high values (about 30 and 46 $K_{30°C}\cdot10^3$).

Plankton

A. Quantitative Analysis of Plankton

The plankton samples were hauled at 32 stations (Fig. 1). As shown in Fig. 3, A, the settling volume of total plankton was relatively small throughout all stations. It was largest in the outer half of the bay, and smallest in two inlets, Onagawa and Nonohama. The total number (Fig. 3, B) was also very small throughout all stations,

Fig. 3. Distribution of plankton in Onagawa Bay (August 28, 1951).

A. Distribution of settling volume (cc) per one m haul from the 5 m depth to the surface.

B. Distribution of total number of plankton (unit of number is thousand).

C. Distribution of total number of zooplankton per one m haul (unit of number is thousand).

D. Distribution of total number of phytoplankton in cells or colonies per one m haul (unit of number is thousand).

proportionally to the settling volume. The largest number of individuals, cells or colonies measured at the northeastern area was only 3–3.3 thousands per one m haul, and the smallest number was about 0.4 thousands per one m haul in the inlet of Nonohama.

The relation between the settling volume and number (Fig. 4) is generally parallel in the inner part of the bay. In the outer part of the bay, however, it is not the

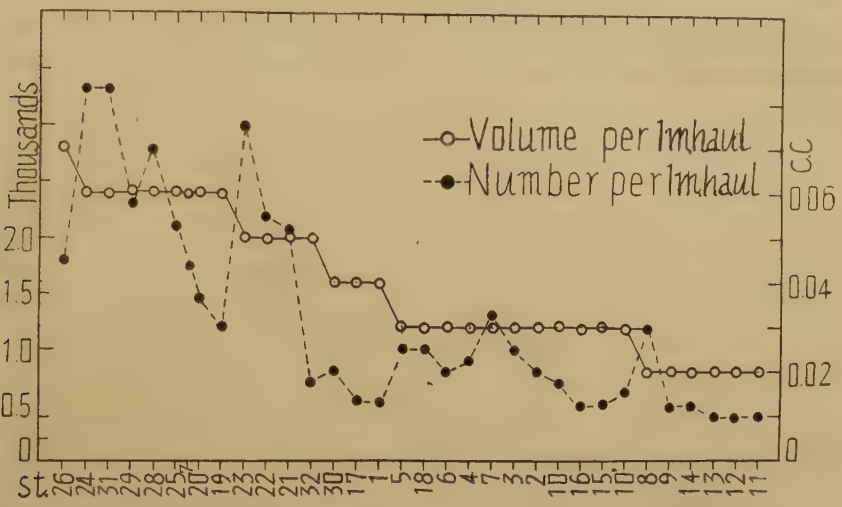

Fig. 4. Relation between settling volume (cc) and total number of individuals, cells or colonies of plankton at each station (each per one m haul).

case, since their composition varies at different stations. At St. 24, 31, 23 and 28 the number was very large because of unusual richness of diatoms.

As shown in Fig. 3, C, the population of zooplankton was relatively poor through-

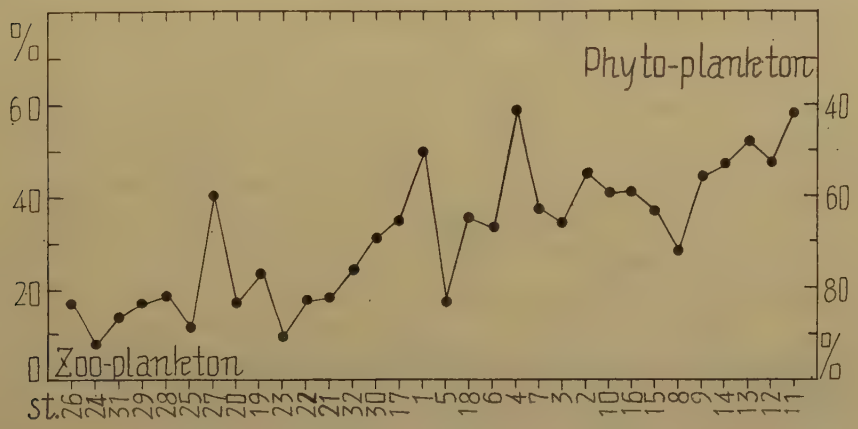

Fig. 5. Percentage composition between total number of zoo- and phyto-plankton per one m haul.

out all stations, but it was found densest in the mouth, and smallest in the central and the inlet of Nonohama. The numerical percentage of zooplankton in the total plankton (Z/N×100) was very large, more than 10–20% in the mouth and 30–60% in both inlets (Fig. 5).

The population of phytoplankton was the densest in the outer half of the bay, where the number was only less than 3.3 thousands cells or colonies per one m haul. It was the thinnest in the inner part of both inlets as in the case of zooplankton. The numerical percentage of phytoplankton in total plankton (P/N×100) was relatively

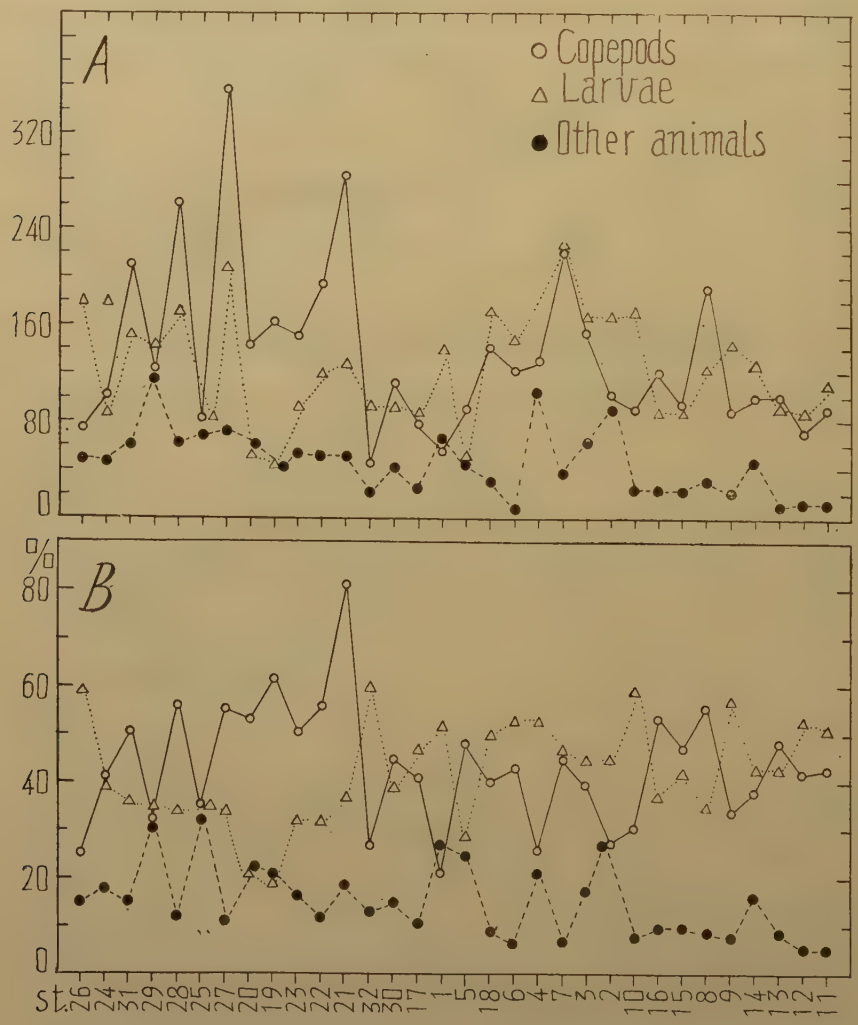

Fig. 6. Population of zooplankton groups per one m haul (above), and their percentage composition (below).

small as compared with all the bays I formerly surveyed. The value was large in the mouth (about 80–90%) and decreased towards the inner region and attained the minimum in the Nonohama inlet (about 50–60%),

B. Qualitative Analysis of Plankton

ZOOPLANKTON

As shown in Fig. 6, the most important component of zooplankton was copepods (30–60%). The next was larval forms of various animals, such as polychaetes, molluscs, copepods and ascidians, all of which were represented by 20–60% in total zooplankton. The other animals such as protozoans, medusae, rotifers, chaetognaths, tunicates and cladocerans, etc. were represented by 5–30%.

The copepods, which are relatively large in size, form the most important population in this bay. The main components of copepods of the bay were almost similar at all stations, but they varied in the population density and its percentage composition. Among copepods the following 15 species were remarkable: *Acartia clausi* (1–75%),

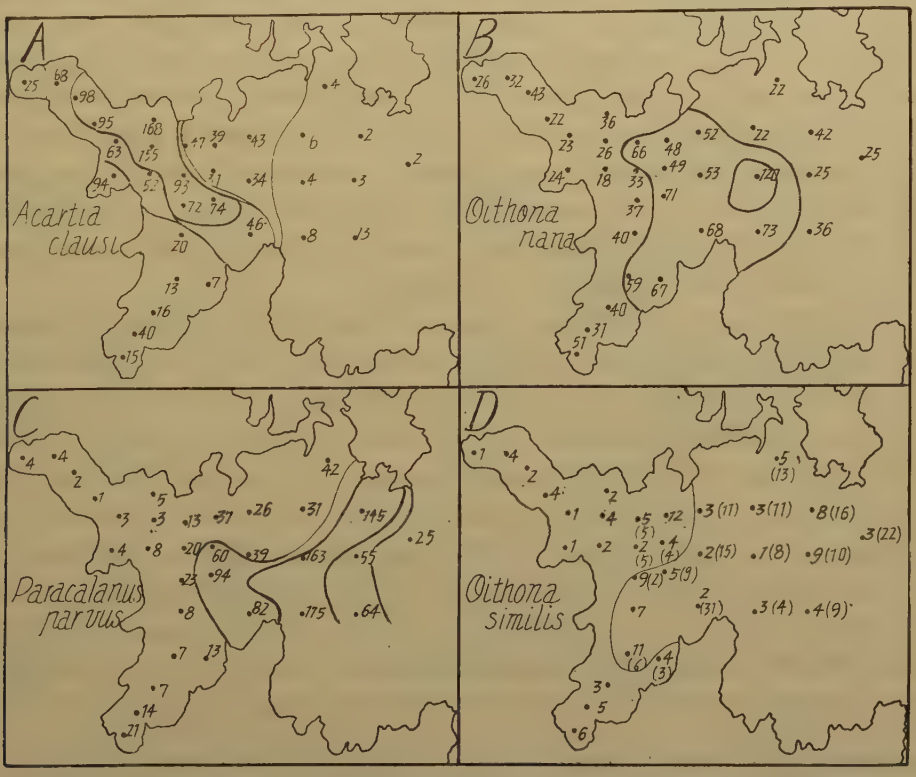

Fig. 7. Distribution of important copepods from the 5 m layer to the surface. The number in parentheses shows the average number of individuals from the bottom to the 5 m depth per one m haul.

Oithona nana (4–63%), *Paracalanus parvus* (1–70%), *Oithona similis* (0–15%), *Microsetella norvegica* (0–8%), *Oncaea media* (0–55%), *Oncaea venusta* (0–12%), *Euterpe acutifrons* (0–4%), *Oithona rigida* (0–5%), *Oithona plumifera, Calanus minor, Cal. pauper, Cal. darwinii, Calocalanus pavo, Copilia longistylis* (each less than 1%), etc. Of these species the last six are of the offshore origin, and they occurred scarcely in the outer part of the bay. *Acartia clausi* (Fig. 7, A and Fig. 9) predominated and occurred mainly in the Onagawa inlet, where it attained about 50–160 individuals (20–80%) per one m haul. *Euterpe acutifrons* was also restricted to the Onagawa inlet. *Oithona nana* (Fig. 7, B and Fig. 9) was evenly distributed in the bay, although the individual number was observed most abundantly in the central region (50–120 individuals) and decreased towards the Nonohama and Onagawa inlets as well as towards the mouth. Its percentage reached 50–65% of the total copepods in the central region and Nonohama inlet and decreased towards the inner part, in contrast with the case of *Acartia clausi*. *Paracalanus parvus* (Fig. 7, C and Fig. 9) predominated in the mouth (about 50–170 individuals and 50–70% in its percentage composition) and decreased towards the inner part (10–40 indivibuals) and smallest in the Onagawa inlet, where *Acartia* was numerous. *Oithona similis* was widely distributed, but it was very sparsely found in the samples from the surface to the 5 m depth, while in the samples from the 5 m depth to the bottom it was relatively numerous (10–20 individuals per one m haul) in the outer half of the bay. *Microsetella norvegica* plus *M. rosea* were widely distributed but very sparsely. *Oncaea media* plus *Oncaea venusta* (this species was very few in number) were rather evenly found from the mouth to the Nonohama inlet, but the former was abundant in the patch at the central region. From the Onagawa inlet *Oncaea* was not obtained.

The cladocerans such as *Penilia schmackeri, Evadne tergestina* and *Podon leuckarti* were widely distributed, though small in number, and they decreased towards the inner part of the Onagawa inlet. Among chaetognaths, an oceanic form *S. enflata* was only found at the outer stations very sparsely. A neritic form *Sagitta delicata*, on the other hand, was widely distributed throughout all stations (Fig. 8, D). *Oikopleura dioica* and *O. longicauda* were also found, though the latter species was more abundant than the former (Fig. 8, C). The other tunicates *Fritillaria haplostoma*, and *Doliolum nationalis* were distributed in the outer region. *Favella campanula, Tintinnus lusus-undae* and a rotifer *Encentrum* sp. were restricted to the inner region. Radiolarians, *Noctiluca scintillans* and *Stycholonche zanclaea* were only sparsely distributed. The larval forms, copepod nauplii (Fig. 8, D) occurred widely in the bay.

PHYTOPLANKTON

Diatoms: Diatoms were important in the outer half of the bay. They were characterized by the dominance especially of the species of *Chaetoceros* and *Rhizosolenia*,

and to a less degree of dinoflagellates in number. The *Chaetoceros* such as *Ch. affinis, Ch. didymus, Ch. laciniosus* and *Ch. subsecundus* were relatively abundant throughout all stations except the Onagawa inlet where diatoms were very poor. *Rhizosolenia calcar-avis, Rh. alata* forma *gracillima, Rh. styliformis* and *Rh. hebetata* forma *semispina* were also important in the occurrence. The first two were relatively abundant at all stations, but the latter two were found chiefly at the outer stations. *Thalassiothrix Frauenfeldii*, on the contrary, was richer in the Onagawa inlet than in the outer half of the bay, though not found in the Nonohama inlet. Oceanic warm

Fig. 8. Distribution of important copepods (A, B), tunicates (C) and larvae of animal groups (D). The number in the circle in D shows the individual number of animal groups except copepod nauplii.

water forms such as *Ch. coarctatus, Ch. peruvianus, Rh. Bergonii, Climacodium Frauenfeldianum, Ch. biconcavum* appeared also, though only in very small numbers in the outer part of the bay.

Dinoflagellates: The dinoflagellates were subdominant in abundance and 13 species were recognized in the sample. Of these, *Pyrocystis noctiluca, Ceratium candelabrum, C. smatoranum, C. macroceros*, and *C. trichoceros* were moderately abundant

Table 1. Individual number per 1 m haul of each species obtained by the vertical haul.

Station number	5 (Inner part of the bay)								32 (Outer part of the bay)				
Hauled depth (m)	0-1	1-3	3-5	5-10	10-15	15-20	20-25	25-30	0-5	5-10	10-20	20-30	30-43
Copepods (total)	148	270	256	57	48	14	20	23	53	71	65	11	34
Paracalanus parvus	4	37	35	16	1	1	—	—	18	25	12	2	8
Acartia clausi	130	153	156	37	30	6	9	8	2	1	—	1	2
Oithona similis	1	4	3	4	4	5	1	—	3	2	22	13	3
Oithona nana	5	66	60	9	9	3	3	2	18	40	8	2	7
Oithona rigida	2	1	—	—	—	—	—	—	—	—	—	—	—
Microsetella norvegica	2	—	—	—	—	—	—	—	—	—	—	—	—
Euterpe acutifrons	2	—	1	—	3	1	1	—	—	—	—	—	—
Oncaea venusta	2	—	—	—	—	—	—	13	1	1	4	1	1
Oncaea media	2	9	1	1	1	2	6	13	10	2	19	2	13
Other animals (total)	44	53	42	4	7	1	2		18	17	32	4	19
Penilia schmackeri	2	9	6	1	1	—	—	—	—	—	6	1	6
Evadne tergestina	3	14	8	2	1	—	—	—	3	2	—	—	2
Podon sp.	3	2	2	1	—	—	—	—	—	—	—	—	—
Sagitta delicata	4	11	2	—	1	—	1	—	—	—	4	—	—
Oikopleura longicauda	—	—	—	—	—	—	—	—	3	6	2	1	1
Oikopleura dioica	28	17	24	—	4	1	1	—	12	9	20	2	12
Encentrum marinum	4	—	—	—	—	—	—	—	—	—	—	—	—
Larvae of animals (total)	56	99	105	40	80	65	68	29	94	52	36	8	52
Polychaeta larva	3	—	—	—	—	—	—	—	2	—	—	1	—
Pelecypoda veliger	—	—	—	—	—	—	—	—	6	—	—	—	—
Gastropoda veliger	3	12	2	—	—	—	—	—	1	—	—	—	10
Copepoda juv. and nauplii	50	85	103	40	80	65	68	29	85	52	36	7	42
Total number	248	422	403	101	135	80	90	52	165	140	133	23	105

in the outer part of the bay, although they were widely distributed. *Peridinium grande, Per. Oceanicum* var. *oblongum, C. fusus, C. furca* and *C. deflexum* appeared very sparsely in the inner part of the bay.

C. Observations on the Vertical Distribution of Zooplankton

The vertical distribution of zooplankton was observed in detail at the mouth (St. 32) and inner part of the bay (St. 5), measuring about 43 m and 30 m in depth respectively. As shown in Table 1, plankton were hauled with the similar closing

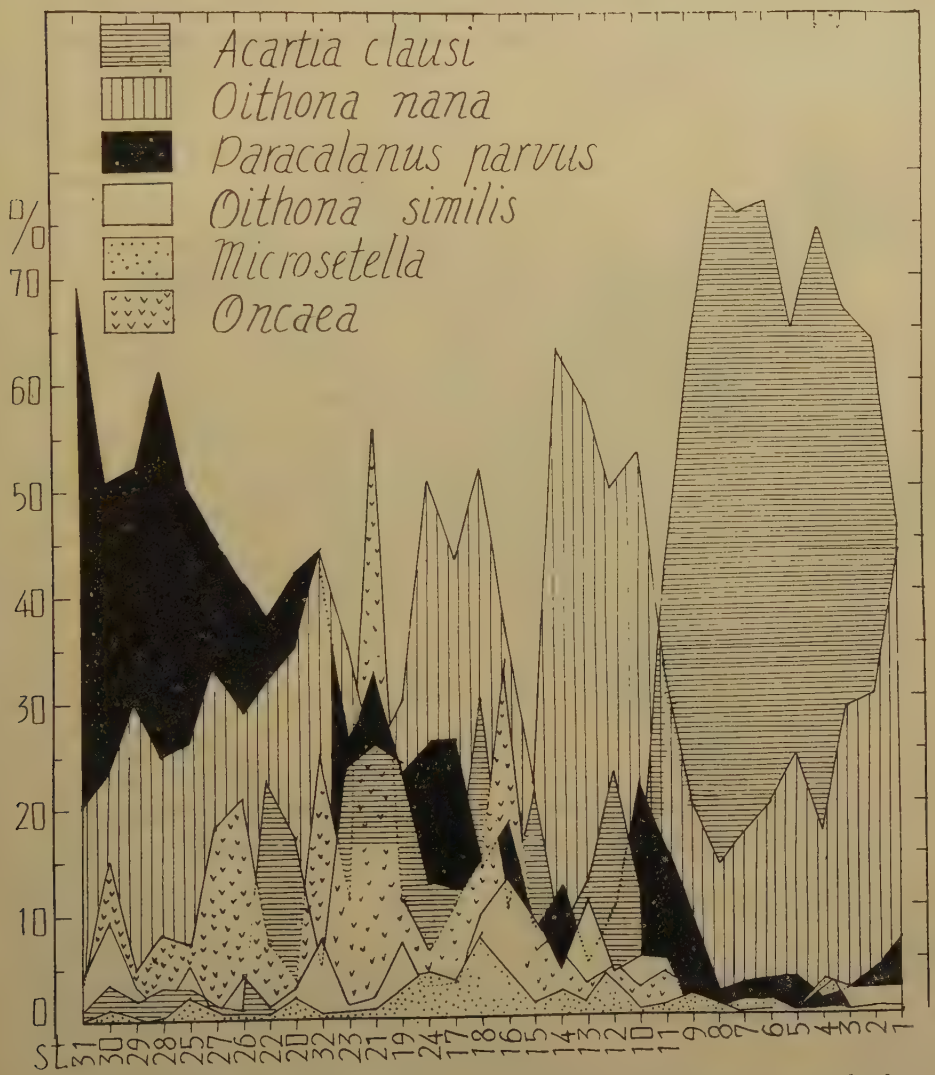

Fig. 9. Percentage composition of important copepods per one m haul between surface and 5 m depth.

net at different depths. The result showed that some species were distributed more fairly in the upper layers at the inner station than at the mouth station. *Oithona similis* was found more abundantly in the lower layer than in the upper layer. On the other hand, the inshore forms were found in the upper layers, in a range of 1–10 meters at St. 5 and 5–20 meters at St. 32.

Consideration on Regional Distribution

As clear from the data described above, plankton communities in Onagawa Bay consist of various components. It is reasonable that they are directly or indirectly

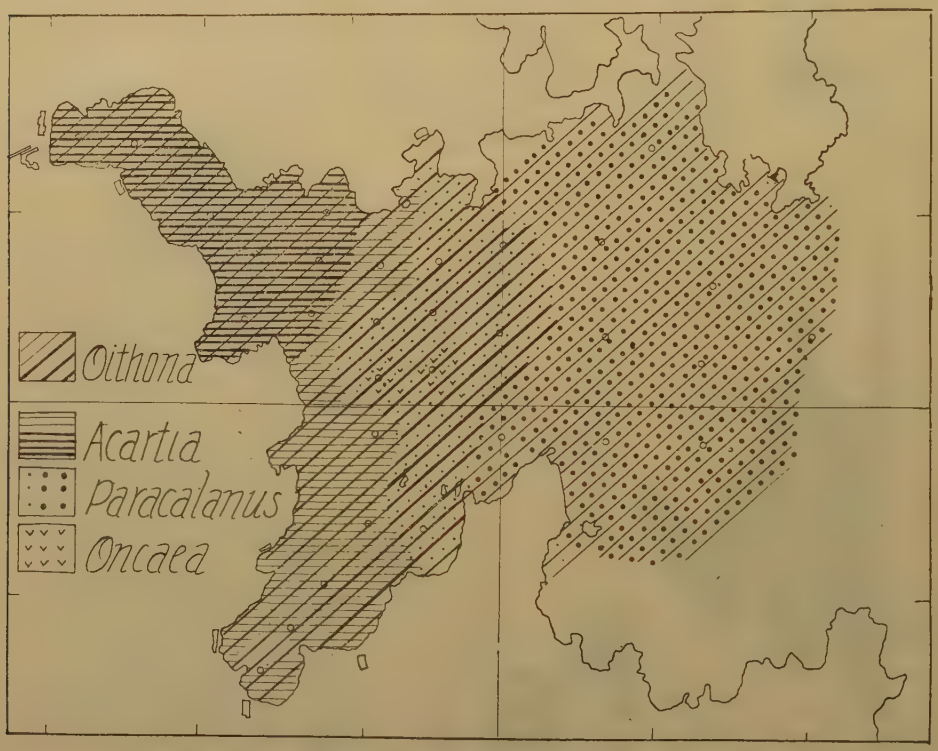

Fig. 10. Distribution of dominant copepods in Onagawa Bay.

influenced by the peculiar topographical and hydrological character of the bay, since the bay is a deep rias inlet opened directly to the ocean with a rather wide mouth.

According to the distribution of the dominant copepods and their relative abundance, the following three communities and three faciations may be recognized (Fig. 9 and Fig. 10).

1. *Acartia clausi—Oithona nana* community.

The area of the Onagawa inlet was abundantly occupied by *Acartia clausi* community, associated with many of *Oithona nana* and their nauplii. The other associates were *Paracalanus parvus, Euterpe acutifrons, Oithona similis, Microsetella norvegica, Oikopleura dioica, Sagitta delicata, Favella campanula, Encentrum* sp. and larval forms such as pelecypod, gastropod veligers and polychaete larvae. Associated diatoms were, for example, *Chaetoceros affinis, Ch. laciniosus, Rhizosolenia hebetata* forma *semispina, Rh. calcar-avis* and *Rh. alata* forma *gracillima.*

The animal productivity was relatively large, although the vegetatives were of lesser importance than in the outer areas.

The water of this area was highly stagnant and yellowish brown in color with small transparency in the surface layer. The surface water showed a tendency of relatively low salinity, and it tends to be, as a whole, colder in winter and hotter in summer than in the other areas of the bay.

2. *Oithona nana* community.

The Nonohama inlet and the central part of the bay were densely occupied by a small copepod *Oithona nana.* It was associated with *Paracalanus parvus, Acartia clausi, Oithona similis, Oncaea venusta, Penilia, Evadne, Oikopleura dioica, Sagitta delicata,* copepod nauplii, molluscs veligers. As diatoms, *Ch. affinis, Ch. didymus, Ch. subsecundus, Rh. hebetata* f. *semispina, Rh. calcar-avis* and *Bacteriastrum hyalinum* were found. Dinoflagellates such as *Ceratium macroceros, C. trichoceros, C. tripos* forma *atlantica, Pyrophacus horologicum* and *Pyrocystis noctiluca* occurred there.

The population density represented by this community was much larger than that in the preceding community in the Onagawa inlet. In this area the association sometimes showed marked local variations, and the following three faciations were observed.

(a) *Oithona nana—Acartia clausi* community.

In the inward area of the central region and Nonohama inlet, *Oithona nana* occurred together with large number of *Acartia clausi.* The productivity of this area was relatively small.

(b) *Oithona nana—Oncaea* community.

In the central region, *Oithona nana* occurred together with large number of *Oncaea media* and small number of *Oncaea venusta.* The productivity was larger than that of the preceding area.

(c) *Oithona nana—Paracalanus parvus* community.

The northern area of the central region was predominated by *Paracalanus parvus,* besides *Oithona nana.* The productivity was very large.

3. *Paracalanus parvus—Oithona nana* community.

Paracalanus parvus was a predominant component of the plankton near the mouth

of the bay as usual in other bays. Besides, there were found the neritic copepods such as *Oithona similis, Microsetella, Oncaea venusta* and *O. media*, and the oceanic forms such as *Calanus darwinii, Cal. pauper, Eucalanus attenuatus, Sagitta enflata, Oikopleura longicauda, Fritillaria, Doliolum nationalis, Pyrocystis noctiluca, Pyrophacus horologicum, Ceratium candelabrum, Cer. trichoceros, Cer. deflexum* and *C. smatoranum*, and diatoms such as *Chaetoceros coarctatus, Ch. peruvianus, Rh. hebetata* f. *semispina and Rh. calcar-avis.*

This area is relatively deep and the water shows higher transparency and lower water color and higher salinity than in other inner areas. There are numerous indications of intrusion of oceanic influence into the bay.

Among these communities there were marked differences in composition and abundance. For instance, *Acartia* is the most abundant in the inner area but sparse in the outer. The warm-water oceanic species, such as *S. enflata*, calanoid copepods and dinoflagellates and diatoms, were found numerously in the outer area. The appearance of these species can be regarded as an indicator of water mass exchange.

Generaly speaking, the plankton community of Onagawa Bay is largely occupied by the *Oithona nana* and *Paracalanus parvus* communities. The *Acartia* community is rather restricted to the Onagawa inlet. The offshore forms brought from the mouth into the central region of the bay where is the area largely occupied by *Oithona nana—Oncaea* community relatively abundant. And it is also remarkable in this bay that the plankton productivity is very small in this survey, as is the case with the outer region of Imari Bay, Kyusyu (YAMAZI, 1952 a).

Summary

1. The qualitative and quantitative survey of the plankton of Onagawa Bay was made in August of 1951.

2. The densest population of zoo- and phytoplankton was found in the central region of the bay, but as a whole the plankton community of the bay was poor, apparently as a result influenced by a direct oceanic influx.

3. In Onagawa Bay, three plankton communities and three faciations in relation to the distribution and abundance of important copepods and their associates were distinguished, that is (1) *Acartia clausi*, (2) *Oithona nana*, (2a) *Oithona* associated with *Acartia* (2b) *Oithona* associated with *Oncaea* (2c) *Oithona* associated with *Paracalanus*, and (3) *Paracalanus parvus* and *Oithona nana* communities.

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PLANKTON INVESTIGATION IN INLET WATERS ALONG THE COAST OF JAPAN

X. THE PLANKTON OF KAMAISI BAY ON THE EASTERN COAST OF TÔHOKU DISTRICT[1)]

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With 16 Text-figures

In Kamaisi Bay on the eastern coast of the Tôhoku District, about 100 km north of Onagawa Bay, a planktological survey was made by the same method as already mentioned on September 30, 1952. In this survey, the writer owed to the

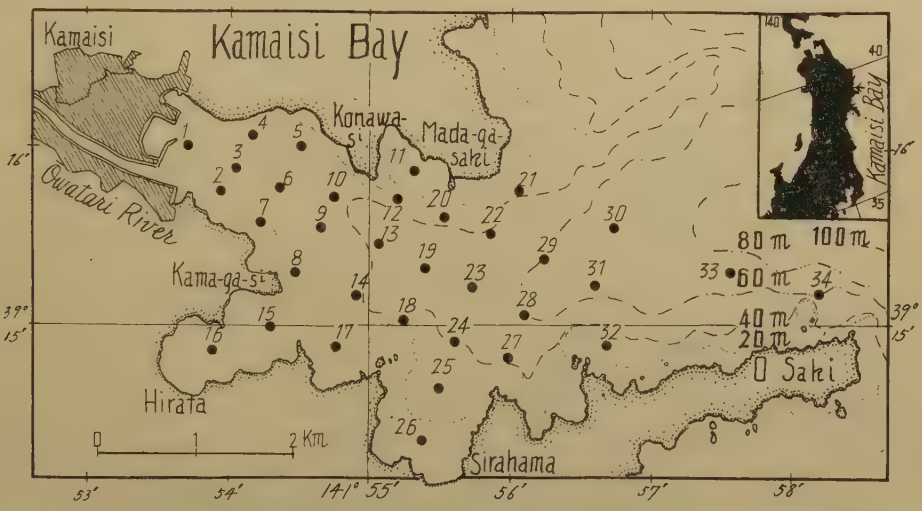

Fig. 1. Chart of Kamaisi Bay showing stations and bathymetric contours.

Iwate Prefectural Fisheries Experimental Station for permission to use the research boat. At this place the writer extends his sincere thanks particularly to Mr. K. GUNZI, Director of the station, and to Mr. T. HIROSE who participated in various ways of the investigation.

1) Contributions of the Seto Marine Biological Laboratory, No. 217.

Hydrological Conditions

Kamaisi Bay, lying on the north of Onagawa Bay, faces the Pacific Ocean with a rather wide mouth, about 2.5 km across. The interior of the bay is formed of three small inlets, named Kamaisi, Hirata and Sirahama respectively. The basin is relatively deeper than that of Onagawa Bay, the greatest depth near the mouth is about 60–80 meters, and 40 m isobath line enters into about the middle of the bay (Fig. 1). A small river Owatari-gawa passing through the Kamaisi city pours into the innermost region

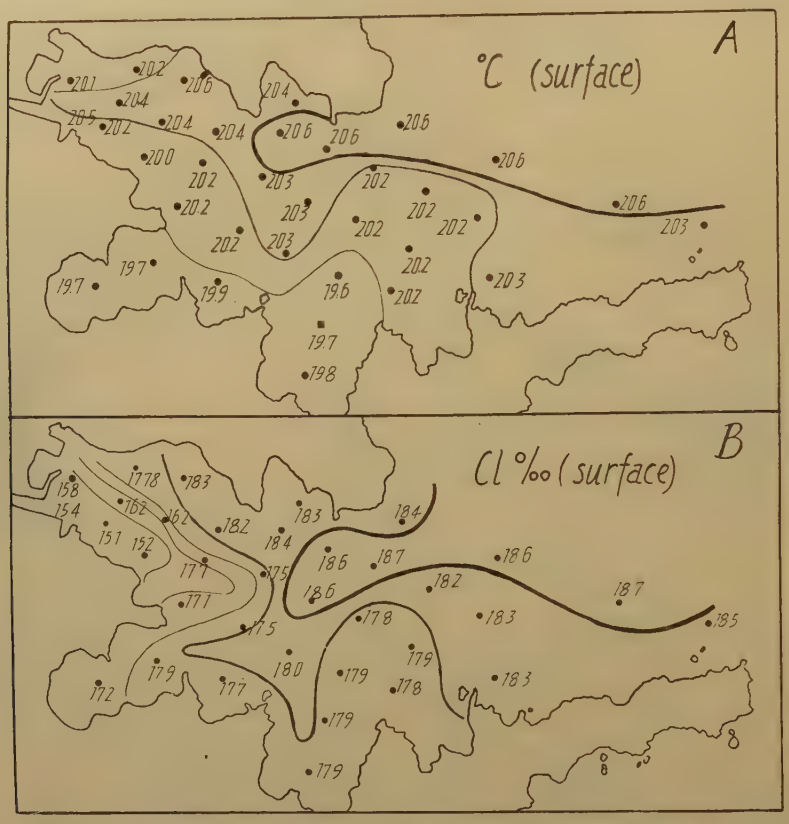

Fig. 2. Hydrological conditions during the survey. (September 30, 1952)
A. Distribution of surface temperature in °C.
B. Distribution of chlorinity in ‰ of the surface layer.

of Kamaisi inlet, and near the mouth many factories of the Kamaisi iron works are situated. Its river water and a large amount of waste discharged from these works influence on the southern area of the bay even towards the cape O-saki out of the bay.

Water temperature (Fig. 2, A); Surface water temperature was relatively uniform as a whole, ranging from 19.6°C to 20.6°C. It was lower in the southern area than in

the northern area and the open sea.

Chlorinity (Fig. 2, B): The lowest chlorinity at the surface was found on the southern half of Kamaisi inlet (15–17 Cl ‰), where the river water pours into the bay. The highest chlorinities were found in the area from the mouth to the middle of the northern area (18.5–18.7 Cl‰), by the inflow of open sea water. In the southern area the chlorinity probably does not differ much from that in the northern area.

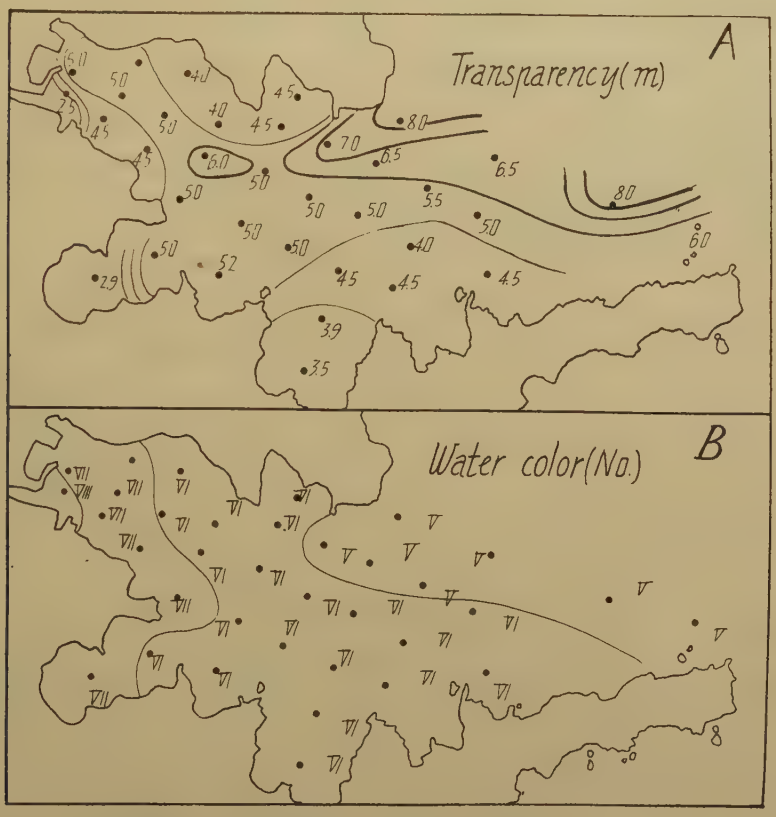

Fig. 3. Hydrological conditions during the survey.
A. Distribution of transparency in m.
B. Distribution of water color in no. of FOREL's scale.

Transparency and water color (Fig. 3, A and B): The transparency of water was 3–5 m in the south and 5–8 m in the northern half of the bay. The water is much discolored near the estuaries of Owatari-gawa, being only 2.5 m in transparency and no. 8 in water colour. The water was clearer along the northern coast and the mouth (no. 5–6 FOREL's scale) than elsewhere.

Plankton

A. Quantitative Analysis of Plankton

The plankton samples were hauled at 34 stations (Fig. 1). The volume and total number of plankton are shown in Fig. 4, which gives respectively the value for one m haul. Both volume and number were very poor throughout all stations, and these were much smaller than in Onagawa Bay. The value was measured, ranging from a maximum of 0.03 cc to a minimum of 0.002 cc in the case of the volume and from

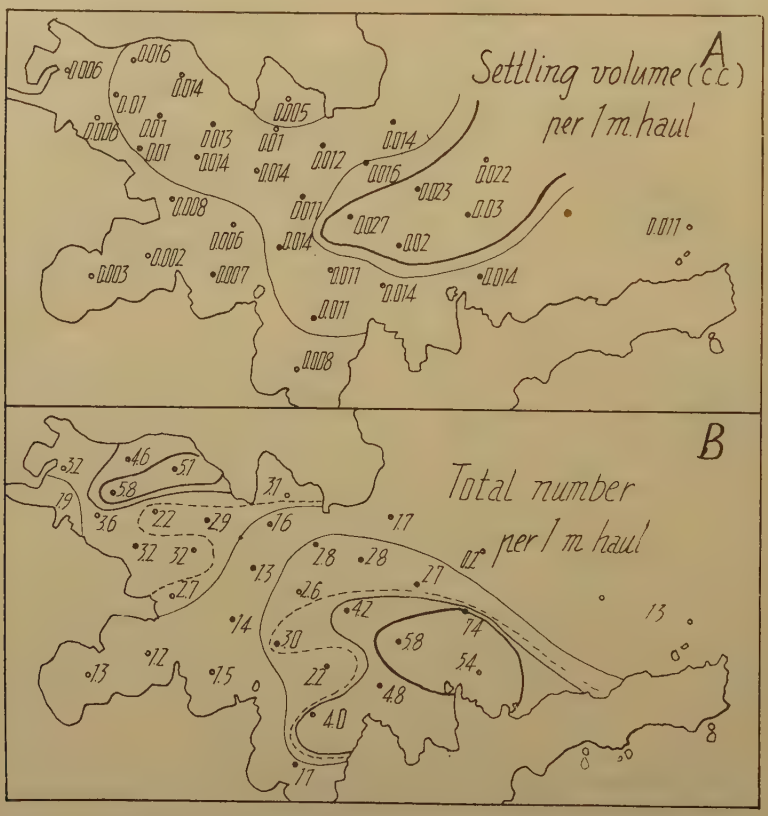

Fig. 4. Distribution of plankton in Kamaisi Bay (September 30, 1952).
A. Distribution of settling volume (cc) per one m haul from 15 m depth to the surface.
B. Distribution of total number of plankton per one m haul (unit of number is thousand).

5.8 thousands to 1.3 thousands of individuals, cells or colonies for total number of plankton per one m haul. The settling volume was the greatest in the central part of the mouth, and smallest in the Hirata inlet. The total number of individuals, cells or colonies was

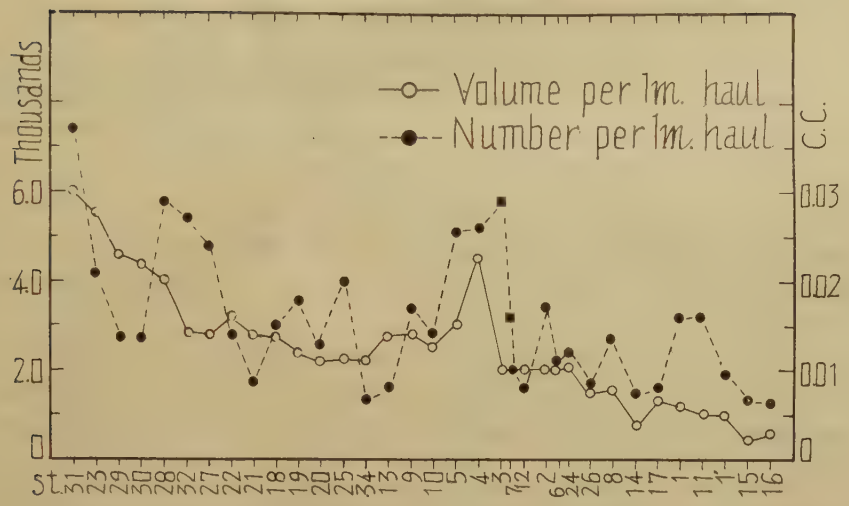

Fig. 5. Correlation between settling volume and total number of individuals, cells or colonies per one m haul.

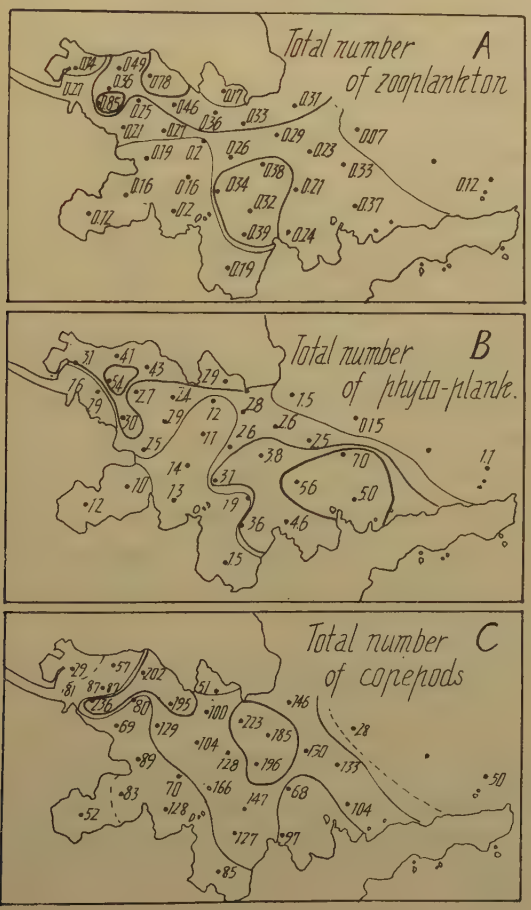

Fig. 6. Distribution of plankton in Kamaisi Bay.

A. Total number of zooplankton at each station (unit of number is thousand).

B. Total number of phytoplankton at each station (unit of number is thousand).

C. Total number of copepods (unit of number is individual).

the largest in the south-eastern part of the mouth and smallest in the central area across the bay from the Hirata inlet to the cape Mada-ga-saki of the mouth.

The relation between the settling volume and total number of plankton is generally parallel except for the outermost part of the bay, where the number was very small, but the volume was relatively large because of the large size of plankton (Sts. 29, 30, 21, 23, 13 and 34)(Fig. 4 and 5). From the inner part to the southern coast of the bay the number increases greatly. It is clear that this is due to the increase in number of diatoms. In most parts of the Kamaisi and Hirata inlets, both volume and number are very small.

The population of zooplankton was poor throughout all stations as in the case of Onagawa Bay (Fig. 6, A). It was, however, largest in the middle area of the Kamaisi inlet, and smallest in the mouth and southern two inlets. The numerical percentage

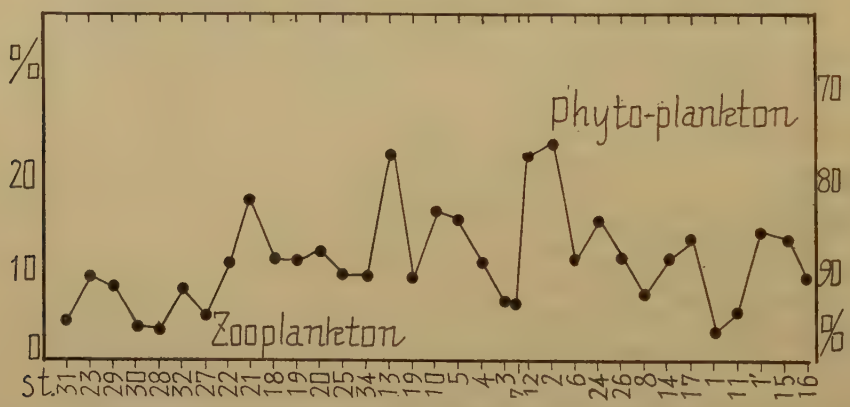

Fig. 7. Percentage composition between zoo- and phytoplankton per one m haul.

of zooplankton in the total plankton (Fig. 7) was also large as in the case of Onagawa Bay. The values generally increased towards the inner part of the bay. The population of phytoplankton was also poor (Fig. 6, B); it was, however, found denser in the southern area of the mouth (about 5–7 thousand cells or colonies and 93–97% of total plankton) and northern part of the Kamaisi inlet (about 3–5 thousands and 85–94%) than in the northern (about 2–3 thousands), mouth region (about 0.2–1.5 thousands and 90–96%) and southern area including two inlets, Hirata and Sirahama (about 1–1.5 thousands and 86–91%)(see Fig. 7).

B. Qualitative Analysis of Plankton

ZOOPLANKTON

As shown in Fig. 8, the important components of zooplankton were copepods (20–65%), protozoans (10–65%), the other various animals (1–10%) and larvae of animals (10–65%). Of these animal plankters, the copepod was the most important

in numerical abundance and frequency of occurrence. Fig. 8 shows the variety of number and percentage composition at each station. The total number of copepods (Fig. 6, C) was greatest in the Kamaisi inlet, while towards the estuary of Owatari-

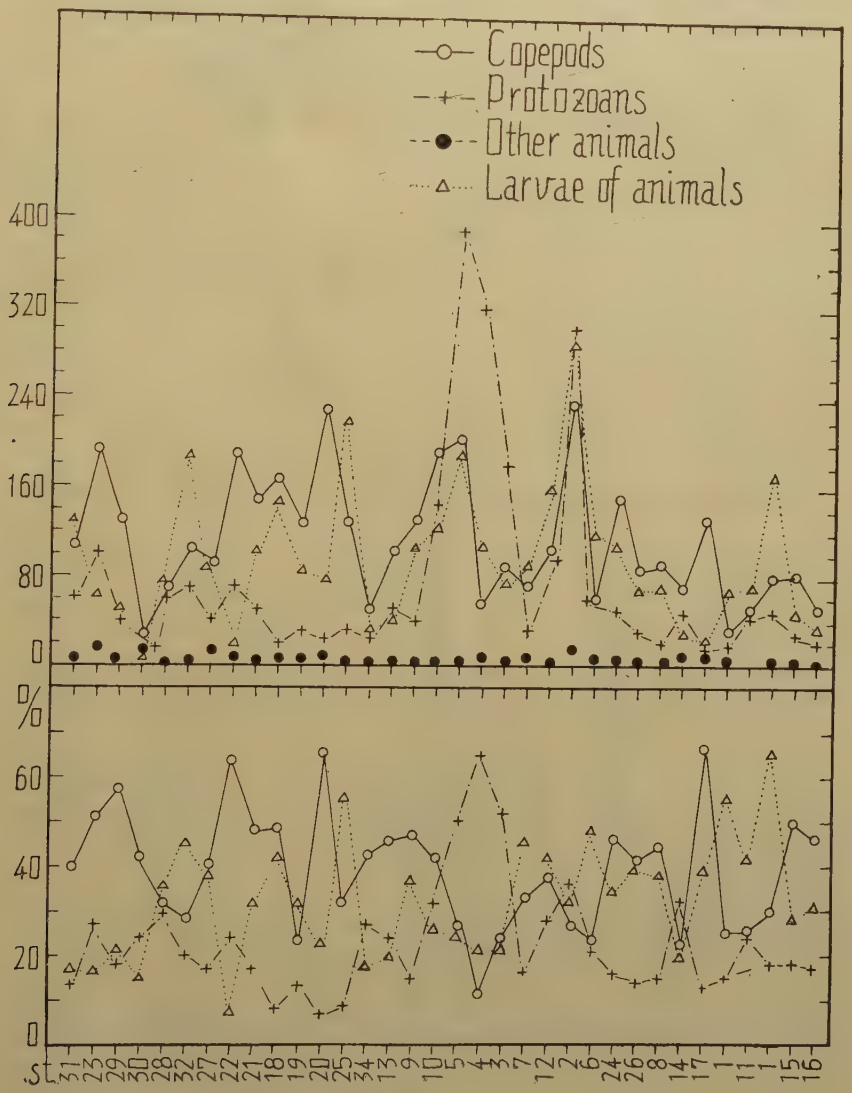

Fig. 8. Number of zooplankton groups per one m haul (above), and their percentage composition (below).

gawa and towards the southern outermost part of the bay it suddenly decreased. And also it decreased outwards the bay from the center of the bay.

Among the copepods the following 28 species were remarkable (unit of number is individual per one m haul).....See Table on p. 198.

Fig. 9. Distribution of important copepods per one m haul.

Fig. 10. Distribution of important copepods per one m haul.

Among them the offshore and neritic species were widely distributed throughout all stations except the innermost part of Kamaisi and Hirata inlets.

Oncaea media (Fig. 9, A and Fig. 11) was predominant among copepods, and occurred mainly in the central region of the bay, where it reached about 50–110 individuals and 30–65% of the total copepods per one m haul. It was, however, comparatively sparse in the mouth and innermost part of the Kamaisi inlet. *Paracalanus parvus* (Fig. 10, C) was abundant in the northern half of the bay and decreased towards the southern half and the mouth (about 10–60 individuals and 7–40% of the composition. *Euterpe acutifrons* (Fig. 10, A) was rather restricted to the Kamaisi inlet (about 20–100 and 10–52%), being only sparsely found elsewhere (about 1–20 individuals and 1–20%).

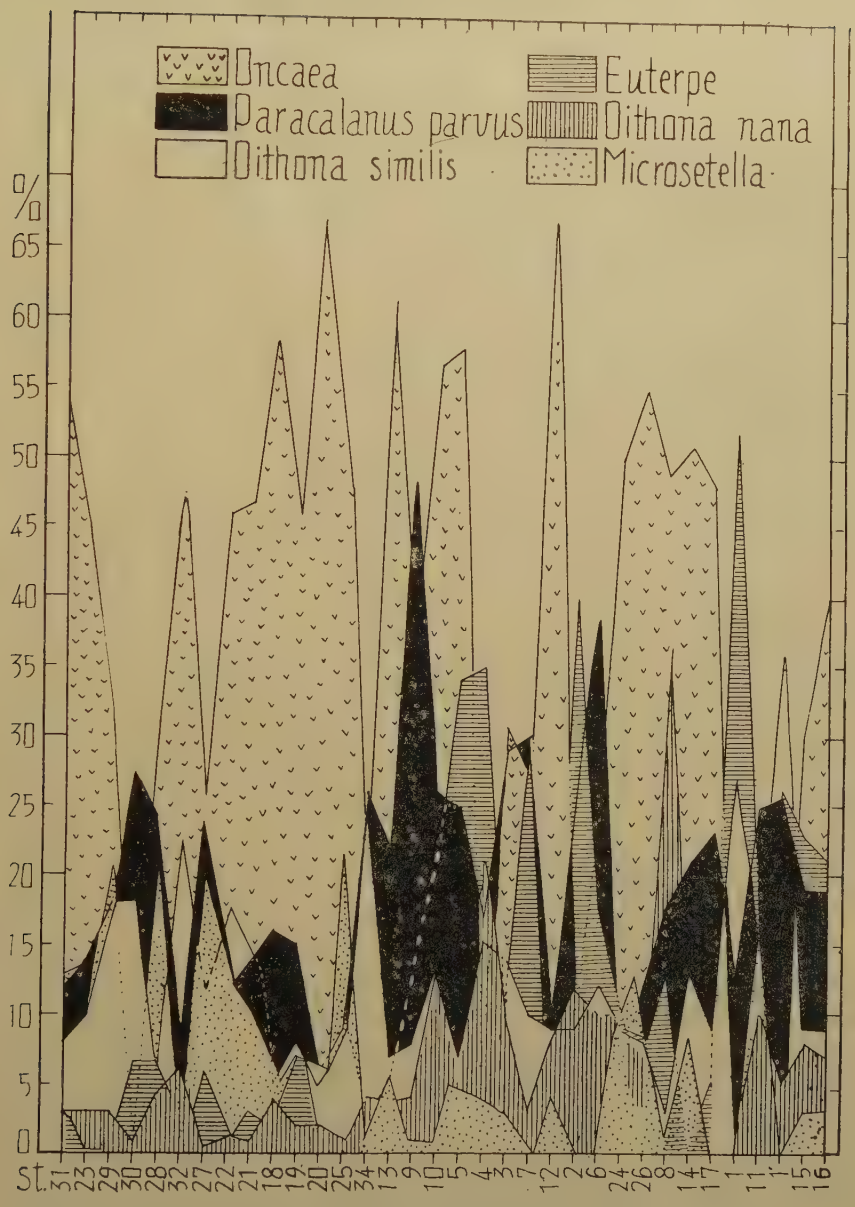

Fig. 11. Percentage composition of important copepods per one m haul at each station.

Species \ Number of individual	Kamaisi inlet	Hirata inlet	Sirahama inlet	Southern area of the bay	Northern area of the bay	Mouth of the bay
Oncaea media	3–58	30–39	45–55	30–58	35–67	20–54
Paracalanus parvus	13–46	19–20	9–12	20–30	12–26	12–27
Euterpe acutifrons	2–52	22–23	8–11	1–23	1–10	2– 3
Oithona similis	3–36	9–10	8– 9	5–13	5–17	8–24
Oithona nana	0–32	7–14	1– 2	1–14	2–12	0– 6
Microsetella norvegica	0– 5	2– 3	12–20	2–20	1–14	1–13
Coricaeus crassiusculus	0– 3	+	+	+	+	0– 3
Oithona rigida	+	+	+	1– 3	1– 3	1– 4
Acartia clausi	0– 3	2	0– 1	0– 2	+	–
Acartia negligens	–	–	–	–	+	+
Centropages bradyi	+	–	–	+	+	2– 7
Clitemnestra rostrata	–	–	–	–	+	–
Oithona plumifera	–	+	+	+	0–4	1– 7
Copilia longistylis	–	–	+	+	+	+– 1
Oncaea venusta	–	–	+	+	+	1– 3
Candacia sp.	–	–	–	+	+	+
Temora discaudata	–	–	–	+	+	+
Temora stylifera	–	–	+	+	+	–
Calanus helgolandicus	–	–	–	+	+	+
Calanus tenuicornis	–	–	+	+	+	+
Calanus minor	+	–	+	+	+	+
Calanus darwinii	–	–	+	+	+	+
Eucalanus crassus	–	–	–	–	+	–
Eucal. attenuatus	–	–	–	+	+	+– 2
Calocalanus pavo	+	–	–	–	+	–
Paracalanus aculeatus	–	–	–	+	+	+
Clausocalanus furcatus	–	–	+	+	+	+
Holoptilus longicornis	–	–	+	+	–	–

Oithona nana (Fig. 10, B) which is a true inlet species showed a similar distribution, although it was markedly smaller in number and percentage composition (about 10–30 individuals and 2–30% from the Kamaisi inlet to the mouth of Hirata inlet, and 1–10 individuals and 1–10% in the other stations) than in the various bays and inlets already surveyed. *Oithona similis* (Fig. 9, C) was of approximately the same number almost everywhere, although more abundant northwards than southwards. *Microsetella norvegica* and *M. rosea* Fig. 9, B) were found chiefly in the central area of the mouth, showing 10–20% and 10–30 individuals, while very scarce elsewhere. *Acartia clausi*, which was the most important component in the inner part of Onagawa Bay, was very sparsely found in the inner part and not found in other outer areas. From the distribution of these neritic forms and their comparative abundance, it seems probable

that the inner area of the bay is affected strongly by the land water. But, at the stations of the central and outer part of the bay were found many oceanic copepods such as *Calanus, Eucalanus, Acrocalanus, Clausocalanus, Copilia, Candacia, Oncaea, Coricaeus,* etc., and they have little intruded into the innermost part of the bay and inlets, as indicated in the appended table (see left).

Fig. 12. Distribution of chaetognaths per one m haul at each station.

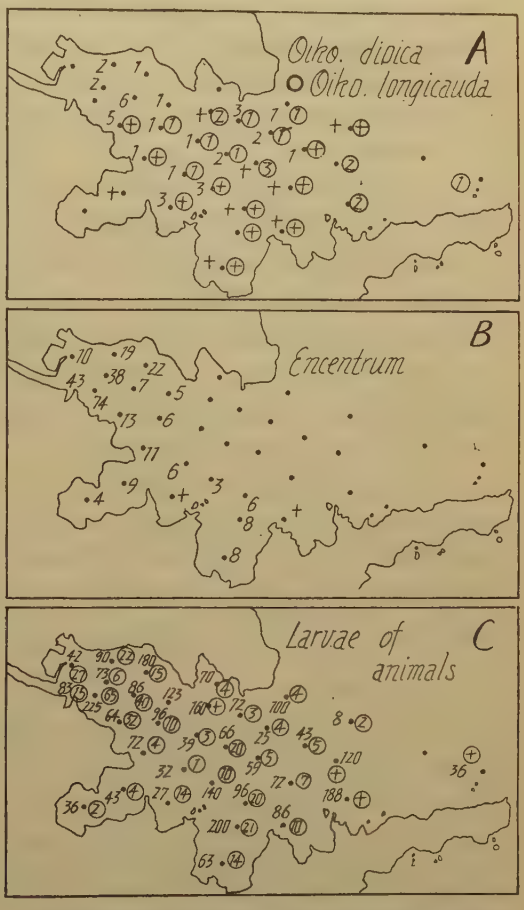

Fig. 13. Distribution of zooplankton. A, The number in the circle shows the individual number of *Oik. longicauda.* C, the number in the circle shows the total number of animal groups except copepod nauplii. The number not encircled shows the copepod nauplii.

The cladocerans such as *Penilia schmackeri, Evadne tergestina* and *Podon* sp. were widely distributed, but they were very scarce. *Sagitta enflata* and *S. minima* both of

which are the oceanic warm water species occurred at almost all stations except for the innermost two inlets, but at each station were found only a few individuals per one m haul (Fig. 12, B and C). *Sagitta delicata* was also widely distributed, but it was very poor (Fig. 12, A). Many small individuals of *Sagitta* were caught at all stations. Among copelates *Oikopleura dioica* and *Oikopleura longicauda* occurred widely in small number (Fig. 13, A). A few individuals of *Fritillaria haplostoma* and *Frit. pellucida* were found in the outer region of the bay. *Doliolum nationalis* was very scarce. A littoral rotifer *Encentrum* sp. (cf. *E. marinum*) was found frequently in the Kamaisi inlet and southern coast area of the bay (Fig. 13, B), while absent in the outer part of the bay. Hydromedusae were found singly in all parts of the bay but could not be determined.

Among protozoans, *Stycholonche zanclaea* was widely distributed at all stations at the frequency of 5–60%, although it was the most abundant in the Kamaisi inlet (about 50–300 individuals and 10–60% of total number of plankton) and decreased gradually outwards. *Favella campanula* was also numerous in the Kamaisi inlet and decreased towards the southern parts of the bay. Of other tintinnoids, *Tintinnopsis beroidea, Tin. cylindrica, Tin. nordquisti, Tin. mortensenii, Coxiella* sp., *Favella ehrenbergi, Rhabdonella longa, Tintinnus lusus-undae, Tin. lectus, Tin. turris, Tin. acuminatus,* and *Rhabdonella* sp. were frequent.

The main components of larval forms were copepod nauplii, larvae of polychaetes and small number of pelecypod and gastropod veligers. Copepod nauplii were numerous all over the bay, and increased towards the inner part of the Kamaisi inlet (Fig. 13, C). The larvae of polychaetes were also distributed widely at all parts, but they were restricted to the inner part of the bay.

PHYTOPLANKTON

The most distinguished features of the composition and population of the phytoplankton were: (1) the poorness in total number; (2) the invasion of many species of oceanic forms into the greater part of the bay; (3) the fairly rich diatoms along the southern coast; (4) the relatively rich dinoflagellates in quantity and quality. The total number of phytoplankton at these stations only amounts to 7 thousands of cells or colonies per one m haul at the richest stations (Fig. 6, B, Fig. 14, A–C and Fig. 15, A–C). The population was composed of diatoms, *Thalassiothrix Frauenfeldii, Chaetoceros didymus, Ch. laciniosus, Ch. curvisetus,* etc., and they occurred considerably in abundance in the northern part of the Kamaisi inlet and along the southern half of the mouth of the bay. The other northern and mouth parts of the bay were also occupied by the same species, associated with the oceanic species which seem to have been directly carried in with the inflowing open sea water.

Many offshore and neritic dinoflagellates were found more abundantly in the outer part than in the inner part, that is, *Ceratium trichoceros, Cer. deflexum* (Fig. 15, C),

Cer. tripos, Cer. candelabrum (Fig. 15, B) and small number of *Cer. masciliense, Cer. macroceros, Cer. intermedium, Cer. molle, Cer. smatoranum, Cer. extensum, Cer. fusus, Cer. furca, Cer. lineatus, Cer. gibberum, Cer. berone, Peridinium grande, Per, pellucidum, Per. oceanicum* var. *oblongum, Per. conicum, Per. depressum, Pyrocystis noctiluca, Pyr. fusiformis, Pyr. lunula, Pyrophax horologicum, Ceratocorys horrida, Dinophysis candata,* and *Din. homunculus,* etc. Besides, still more population with *Chaetoceros coarctatus,*

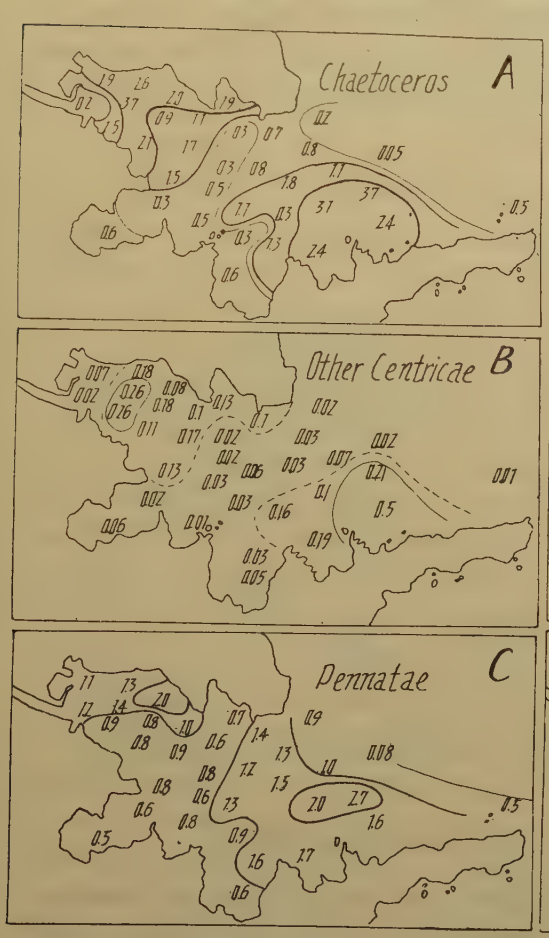

Fig. 14. Distribution of important groups of diatom.

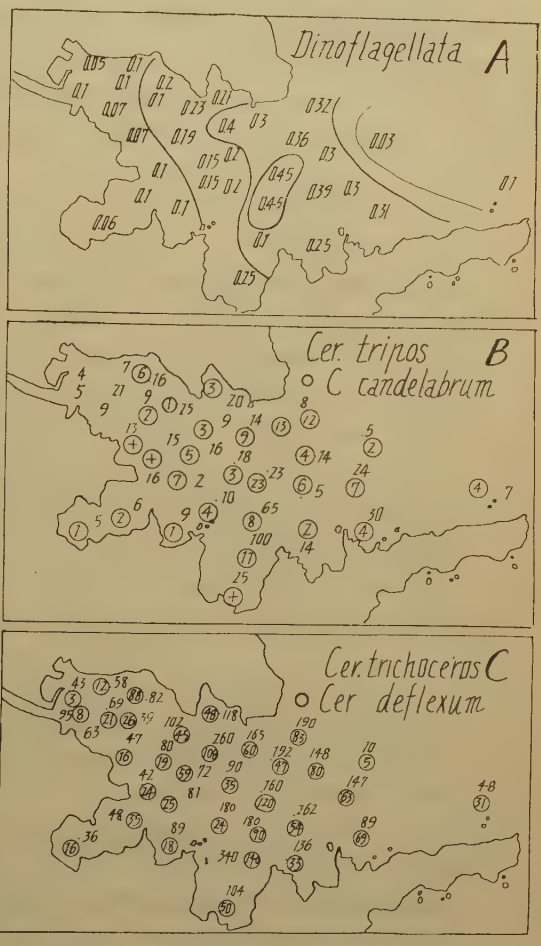

Fig. 15. Distribution of important dinoflagellates.

A. Total number of dinoflagellates (unit of number is thousand).

B. Distribution of *Cer. tripos* and *Cer. candelabrum* (encircled).

C. *Cer. deflexum* (encircled) and *Cer. trichoceros.*

Ch. peruvianus, Ch. tetrastichon, Hemidiscus Hardmanium, Rh. calcar-avis, Rh. alata forma *gracillima* and *Rh. hebetata*, etc. These oceanic diatoms were rather small in number and mingled with many neritic forms. Among the other Centricae, *Ch. atlanticus* var. *neapolitana, Ch. densus, Ch. constrictus, Ch. decipiens, Ch. Lorenzianus, Ch. affinis, Ch. brevis, Ch. costatus, Ch. paradoxum, Rh. setigera, Rh. imbricata, Skeletonema costatum, Coscinodiscus excentricus, Cos.* spp., *Corethron hystrix, Bacteriastrum hyalinum, Dactyliosolen mediterraneus, Leptocylindrus danicus, Climacodium biconcavum, Biddulphia sinensis, Bidd. mobiliensis* and *Hemiaulus Hauckii* were remarkable (Fig. 14, B). The Pennatae, such as *Thalassiothrix longissima, Thalassionema nitzschioides, Asterionella japonica, Pleurosigma* sp., *Nitzschia seriata* and *Navicula* sp. also showed almost the same distribution (Fig. 14, C).

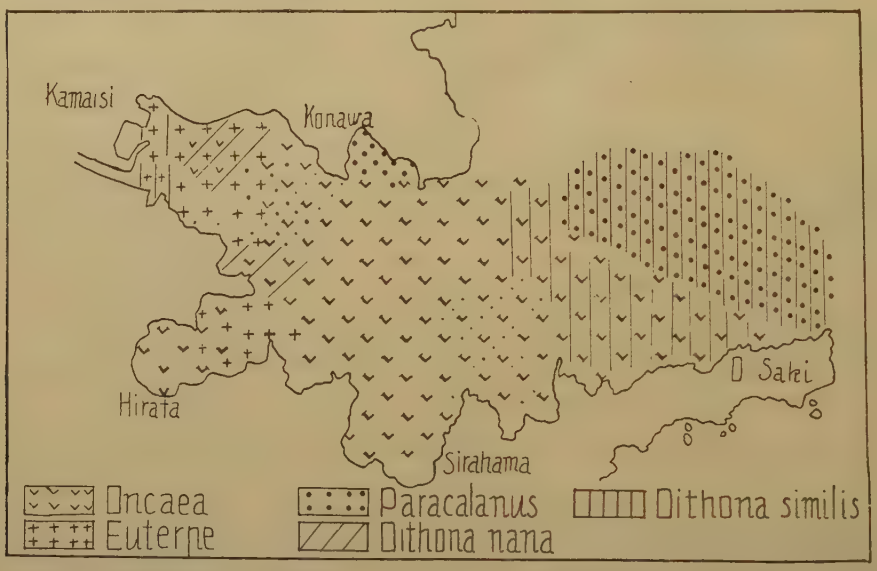

Fig. 16. Distribution of dominant copepods in Kamaisi Bay. (September 30, 1952)

General Consideration on Regional Distribution

The most remarkable feature in this bay is the relatively great abundance of oceanic forms which indicates clearly a strong inflow of Pacific open sea water more than in Onagawa Bay. For example, many of the oceanic forms involving dinoflagellates, diatoms, copepods, chaetognaths and tunicates are evenly distributed in almost all parts of the bay except only the innermost part of the inlet areas.

On the bases of the distribution of the dominant copepods and their relative abundance in this bay, the following three main communities may be recognized as shown in Fig. 16.

1. *Euterpe* community.

Euterpe acutifrons concentrated in the Kamaisi inlet and was predominant among all plankters in the Hirata inlet. It was associated with *Oithona similis*, *Paracalanus parvus*, *Oncaea media* and small number of *Oithona nana*. As other associates a rotifer *Encentrum* and a copelate *Oikopleura dioica* were remarkable. Abundant neritic diatoms and small number of oceanic diatoms and dinoflagellates occurred also there. The population of both zoo- and phytoplankton was relatively large in this bay. At the innermost stations of the Kamaisi inlet the productivity was very poor; there were found almost all the species occurring in the bay, but in much smaller numbers. The water is less saline and much stagnated and polluted by industrial sewage.

2. *Oncaea* community

At almost all the stations, except for the innermost of the inlet and the mouth, *Oncaea media* is predominant. The whole area occupied mostly by this species was associated with *Paracalanus parvus*, *Oithona similis* and many other oceanic copepods and diatoms. In this area the same local patches of population are found. The productivity is relatively small, although it varied according to stations. The distribution of both zoo- and phytoplankton in this area was somewhat complicated, partly because of the different hydrological conditions favourable to various forms. In the central part of the bay, where the population is much poor, the oceanic inflow is very plentiful and the water turbulence is strong. In the southern area near the coast the productivity is large, occupied by abundant neritic diatoms. Thus it may be supposed that the water in the area is furnished with nutrient salts discharged from the river at the head of Kamaisi inlet, flowing along the southern coast into the bay, even if the surface water is contaminated.

3. *Paracalanus parvus—Oithona similis* community.

The mouth part of the bay was represented mainly by *Paracalanus parvus* and *Oithona similis* in the percentage composition, and associated with *Oncaea*, *Microsetella*, large number of oceanic copepods, tunicates, chaetognaths, protozoans, diatoms and dinoflagellates. The productivity is very small. The water is relatively violent and shows higher transparency and salinity, and lower water color than in the preceding areas occupied by the *Oncaea* community.

Generally speaking, Kamaisi and Onagawa bays, which are formed of short embayments with a wide mouth and deep basin, are much more directly influenced by the open sea water and ocean current than the bays or inlets with the narrow mouth and shallow basin. The water is highly saline even towards the head. The productivity in both bays, which are not far apart from each other, is similarly poor, as compared with that in shallower bays such as Nagasaki, Akkesi and Ago Bay. The

composition and the manner of distribution of plankton, especially of zooplankton of Kamaisi Bay were very different. Although such differences may be partly referred to the seasonal succession, it seems probable that the effect of the topographical and hydrological features characterizing the rias coast is not negligible. From a comparison between the plankton communities of the Kamaisi Bay and Onagawa Bay, it becomes clear that, (1) in Kamaisi Bay there were more numerous oceanic species than in Onagawa Bay in respect to diatoms, dinoflagellates, copepods, tunicates and chaetognaths. (2) The number of species was more numerous in Kamaisi Bay. (3) The innermost area of the inlets in Kamaisi Bay is represented by the communities of *Euterpe acutifrons*, *Oithona similis* and *Paracalanus parvus*, instead of the *Acartia clausi—Oithona nana* community which is usually found in most of the bays.

THREE NEW SPECIES AND TWO NEW RECORDS OF THE GENUS *GLOSSODORIS* FROM JAPAN[1)]

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With 6 Text-figures

The following is a revised list of the Japanese species belonging to *Glossodoris* and the allied genus *Noumea* (see also BABA, 1949).

1. *Glossodoris lineolata* (VAN HASSELT, 1824). Kurosuji-umiushi
2. *Glossodoris marginata* (PEASE, 1860). Shirahime-umiushi (new name)
3. *Glossodoris decora* (PEASE, 1860)=*G. setoensis* (BABA, 1938). (See ALLAN 1947). Seto-iroumiushi
4. *Glossodoris festiva* (ADAMS, 1861)=*G. marenzelleri* (BERGH, 1881). Aoumiushi
5. *Glossodoris pallescens* (BERGH, 1875). Shiro-umiushi
6. *Glossodoris thalassopora* (BERGH, 1879).
7. *Glossodoris alderi* (COLLINGWOOD, 1881)=*G. reticulata* (PEASE, 1866). Sarasa-umiushi
8. *Glossodoris aureopurpurea* (COLLINGWOOD, 1881). Komon-umiushi
9. *Glossodoris sibogae* (BERGH, 1905). Siboga-umiushi
10. *Glossodoris clitonota* (BERGH, 1905). Sesuji-umiushi
11. *Glossodoris katoi* BABA, 1938. Katô-iroumiushi (new name)
12. *Glossodoris maritima* BABA, 1949. Ryûmon-iroumiushi
13. *Glossodoris placida* BABA, 1949. Usuiro-umiushi
14. *Glossodoris sagamiensis* BABA, 1949. Sagami-iroumiushi
15. *Glossodoris florens* BABA, 1949. Hanairo-umiushi
16. *Noumea nivalis* BABA, 1937. Shirayuki-umiushi
17. *Noumea parva* BABA, 1949. Hime-iroumiushi
18. *Noumea purpurea* BABA, 1949. Fujiiro-umiushi

The following species are here added to the above list.

1) Contributions from the Seto Marine Biological Laboratory, No. 218.

1. *Glossodoris shirarae* BABA, n. sp.

Shirara-iroumiushi (new name)

(Fig. 1; Fig. 6, A–B)

The animals of this new species differ from those of *Glossodoris pallescens* (BERGH) and other allied forms in some points of the body colouring. They are about 10–25 mm in total length. The back is very finely tuberculated. General ground-colour whitish above and below, the rhinophores and the gills colourless, the back scattered with a varying number of purple (not black nor carmine red) spots which may also be found on the underside of the mantle. The intramarginal yellow band of the mantle continuous or in places interrupted by white. It is especially marked by having a series of indentations on inside. Labial disk and radula as usual in the genus. The elements of the former bifid at tip. Radula formula 45×37.0.37. First lateral denticulated on both sides, the next laterals with 4–10 denticles on outer margin.

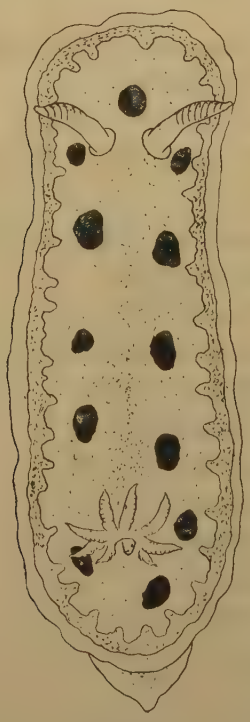

Fig. 1.

Fig. 2.

Fig. 1. *Glossodoris shirarae* (Seto, Mar. 30, 1953. Total length 12mm).
Fig. 2. *Glossodoris nona* (Sagami Bay, Mar. 20, 1951. Total length 25mm).

Loc.: Seto, Kii (Aug. 1951, June 1952 and Mar. 1953, 6 sps., coll. by Messrs. HAMATANI and YAMAMOTO and the present writer); Fushiki and Amaharashi, Toyama Bay (Aug. 1951, 2 sps., coll. by Mr. ABE); Misaki, Sagami Bay (July 1953, 1 sp., coll. by His Majesty's Biological Laboratory).

As there appears to be no species with which the present nudibranch can be identified with certainty, I have given it the specific name *shirarae*, after the local name of Seto, Kii.

2. *Glossodoris multituberculata* BABA n. sp.
Renge-umiushi (new name)

(Fig. 3; Fig. 6, C–E)

A strongly tuberculated glossodorid. Length about 20 mm. Back ornamented with large, elevated, bluntly conical tubercles, with smaller ones between them and

Fig. 3. *Glossodoris multituberculata* (Seto, Aug. 11, 1951. Total length 20 mm). Dorsal and ventral views.

around the branchial opening. With 4 marginal cysts on postero-ventral edge of mantle. General ground-colour almost everywhere chrome-yellow, becoming slightly paler towards the margin of the mantle. Dorsal tubercles tipped with purple. Rhinophores, gills, foot-margin and tip of the oral tentacles purple. Elements of the labial disk bifid at tip. Radula formula 65×30. 0. 30. Rachidial plate not marked. First lateral with 4–5 denticles on either side of the median cusp. Succeeding laterals denticulated on outer edge, the number of denticles increasing from 4 up to 10.

Loc.: Seto, Kii (Aug. 1951, 1 sp., coll. by Mr. HAMATANI).

The present species differs from *Glossodoris nodulosa* (BERGH) in the type of the radula teeth, and from *G. papulosa* (BERGH) in the size and arrangement of the dorsal tubercles.

3. *Glossodoris nona* BABA, n. sp.
Shiraume-umiushi (new name)

(Fig. 2; Fig. 6, F–G)

The simple but fairly unique coloration of this species consists of pure white body-colour with yellow rhinophores and yellow gills, and a number of opaque white spots sparsely set around the mantle-margin. Length of body 25 mm. Labial disk a belt of bifid rads. Radula formula 65×40. 0. 40. First lateral not differentiated (*cf. Noumea nivalis* BABA), and with 4–5 denticles on both sides. Succeeding laterals denticulated on outer margin only, the number of denticles varying from 4 to 10.

Loc.: Amadaiba, Sagami Bay, 80 m (Mar. 1951, 1 sp., coll. by His Majesty's Biological Laboratory).

This species is here regarded as new, with the name *nona* which implies "Miss" in Malay language.

4. *Glossodoris fidelis* (KELAART, 1858)
=*G. flammulata* (BERGH, 1905)
Fujinami-umiushi (new name)

(Fig. 4; Fig. 6, H–I)

A beautifully coloured glossodorid about 15 mm in length. The median part of the back is yellow. It is surrounded by an intramarginal band of purple-red, which turns to orange-yellow near the outer edge of the mantle. On inside the band is irregular, thus sending off a number of tooth-like prolongations directed inwardly. A fine thread of opaque white is visible edging the inner border of the purple-red band. Rhinophores black. Gills 7, also black-tinted. Underside of body yellowish

white. Elements of the labial disk bifid at tip. Radula formula $60 \times 45.0.45$. First lateral denticulated on both sides, the next laterals with 7–8 denticles on outer margin.

Loc.: Seto, Kii (July 1953, 1 sp., coll. by Mr. YAMAMOTO).

Dist.: Indo-Pacific (Ceylon, 'Insel Pajunga,' New Caledonia).

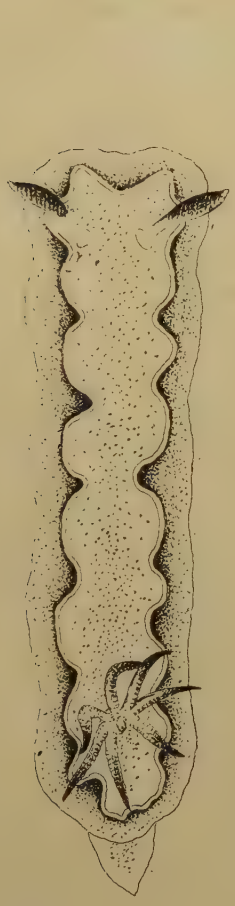

Fig. 4.

Fig. 5.

Fig. 4. *Glossodoris fidelis* (Seto, July 28, 1953. Total length 15 mm). After the original figure taken by Mr. YAMAMOTO.

Fig. 5. *Glossodoris hilaris* (Seto, June 22, 1951. Total length 12 mm).

5. *Glossodoris hilaris* (BERGH, 1890)
Kuchinashi-iroumiushi (new name)

(Fig. 5; Fig. 6, J–K)

The animals before me appear to be a colour variety of *hilaris*, and correspond in all respects to *Chromodoris lineata* of ELIOT (1904, pp. 396–397, pl. 24, fig. 7) from Zanzibar. Total length of body from 15–25 mm. Back ornamented with 5 longitudinal lines of bright purple, of which the median one is obliterated in the type of *hilaris*

Fig. 6. A-B. *Glossodoris shirarae*; C-E. *Glossodoris multituberculata*; F-G. *Glossodoris nona*; H-I. *Glossodoris fidelis*; J-K. *Glossodoris hilaris*. A. A half-row of radula (×550), a. innermost laterals, b. outermost laterals. C. Ditto (×550). F. Ditto (×270). H. Ditto (×550). J. Ditto (×550). B, D, G, I, K. Elements of the labial disk. E. Postero-ventral margin of mantle, showing the opening of the cysts.

(BERGH 1890, pp. 935–937, pl. 86, fig. 4; pl. 87, figs. 11–15), and the rest are apt to fuse together in front and behind so as to enclose the rhinophores and the gills. Sides of body with 2 purple lines. A purple line also surrounding the mantle, the foot-brim and the gill-opening. General ground-colour of back and sides chrome-yellow, the sole whitish, the rhinophores and the gills vermilion. Elements of the labial disk mace-shaped with two lateral protuberances. Radula formula $50 \times 28-30.0.28-30$. All the lateral teeth bicuspidate, each having a few accessory denticles on outside.

Loc.: Seto, Kii (July 1939, June & Sept. 1951, 3 sps., coll. by Mr. YAMAMOTO).

Dist.: Indian Ocean (Zanzibar).

In concluding I wish to tender my hearty thanks to Messrs. Iwao HAMATANI, Torao YAMAMOTO and Takeo ABE for their willing assistance in collecting and studying these beautiful nudibranchs at Seto, Kii or at Abugashima, Toyama Bay. A part of the material was kindly delivered to me by the courtesy of His Majesty's Biological Laboratory.

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STUDIES ON JAPANESE CTENOSTOMATOUS BRYOZOA, I

ON SOME SPECIES OF CARNOSA[1)2)]

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With Plates X–XII and 3 Text-figures

Our knowledge on the Ctenostomata in the north-western Pacific remains yet considerably insufficient. Only 4 Ctenostomata had been recorded from Japan and adjacent seas until Dr. Lars SILÉN (1942) published a paper on Carnosa and Stolonifera collected by Sixten BOCK's expedition to Japan and the Bonin Islands dealing with 14 different species.

So far as I am aware, the first study on Japanese specimens, though has not been published, seems to be attempted by Dr. Alyce ROBERTSON of the University of California on the materials sent by the late Dr. Asajiro OKA. In her letter to Dr. OKA, I have found a list of species she identified. *Alcyonidium gelatinosum* is only one Carnosa seen in the list.

In 1925 Dr. Yaichiro OKADA published a detailed description on a curious new species of *Alcyonidium* proposing a new subgeneric name *Paralcyonidium*. *Al.* (*Paral.*) *vermiculare* is quite distinct in its extremely long, string-like or worm-like body.

In 1933 Dr. OKADA reported *Alcyonidium gelatinosum* from Northern Kurile Islands, and in 1942 SILÉN added 6 species of *Alcyonidium* and 1 species of *Bockiella*.

Among numerous specimens of bryozoans collected by the Biological Laboratory of the Imperial Household, I have found some beautiful Carnosa apparently new to science. The following is the first result of a series of my studies on Japanese Ctenostomata.

Here I express my cordial thanks to Dr. Hirotaro HATTORI, of the Biological Laboratory of the Imperial Household for his kindness in placing valuable materials of the Laboratory at my disposal. I am also greatly indebted to Dr. Katsuzo KURONUMA who kindly gave me materials from Northern Kurile Islands, and to Dr. Lars SILÉN and Dr. Folke BORG in Sweden who helped me in giving their valuable papers.

1) Contributions from the Seto Marine Biological Laboratory, No. 219.
2) Contributions from the Research Institute for Natural Resources, No. 653.

Alcyonidium erectum SILÉN 1942

(Pl. X, Figs. 1–2, Pl. XI, Fig. 7; Text-fig. 1 A–B)

Alcyonidium erectum SILÉN, 1942, Ark. f. Zool., 34A, 8, p. 11, text-figs. 3, 4.

Zoarium: The zoarium is bilaminar, thin and semitransparent, brownish in spirit but recorded by the collector as milky white in fresh materials. The basal end of the colony spreading over the substratum. The branches are somewhat irregular, but usually of the form of narrow braid, sometimes anastomosing. In living state, the conspicuously soft and flexible body seems to sway to and fro in the wave.

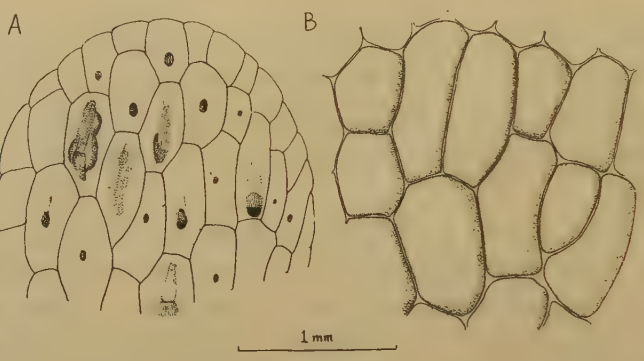


Fig. 1. *Alcyonidium erectum* SILÉN. A. Growing margin of a semitransparent branch. B. Older part of a colony.

Zooecium: The zooecia, arranged in many longitudinal rows, are rather regularly quadrangular or elongate hexagonal in shape. The frontal walls are extremely thin and much transparent that the zooecia of the posterior layer are clearly visible through the anterior layer. The separating walls are thin and a little depressed frontally. The frontal surface is convex, and entirely smooth, with no projections of any kind. The aperture is placed close to the distal end of the zooecium, but difficult to distinguish in the surface view by the fact that there is neither projection nor coloured fold near the orifice. It is only distinguished by the position of the polypide.

Polypide: The polypide is slender, light brown in colour. The vestibule is elongated, extending halfway to the basal wall. The tentacle sheath is slender, going obliquely downwards and then horizontally backwards to the proximal end of the zooecium. The tentacles appeared 22 in number in my cross-sectioned preparations.

The pharynx passes into the slender stomach without distinct depression. The coecum and the intestine are small.

Remarks: The specimen in hand closely agrees with the description and figures of SILÉN, who had only a torn off top end of zoarium. As he has stated, the present

species is not identical with any other known species especially by its branched, thin colony and extremely smooth frontal wall. SILÉN wisely separated this species from his *Alcyonidium foliaceum* in its transparency and absence of kenozooids. The form of the zoarium is, as he has imagined, quite distinct from that of *Al. foliaceum.*

Specimen examined: No. 7626 (Biological Laboratory, Imperial Household Coll. Bry. No. 80) About 2 miles south of Jôgashima, Kanagawa Prefecture, 70 fathoms. July 22, 1935. A complete colony attached to the branch of *Adeona japonica* (ORTMANN), 5.5 cm in height. Width of the branches, 4–6 mm.

Alcyonidium sagamianum sp. nov.

(Pl. X, Fig. 3, Pl. XI, Figs. 1–3; Text-fig. 2)

Zoarium: The zoarium is erect, columnar, branching, large and prominent. It is brownish or grayish in spirit, but the life colour is noted by the collector as cinnamon rufous in general and apricot orange at each tip of branch and attaching base. It stands upright from the unilaminar encrusting base spreading over a stone. The basal part of the upright stem is somewhat constricted in diameter. The branches are small in number, somewhat more slender than the stem tapering gradually to the tips.

The colony is tough to the touch and coarse in appearance for its thickened, chitinous outer layer provided with numerous, crowded, minute mamillae densely distributing all over the surface. It gives something like a spongy feeling and presents distinct elasticity, both probably due to its kenozooecial medullary structure.

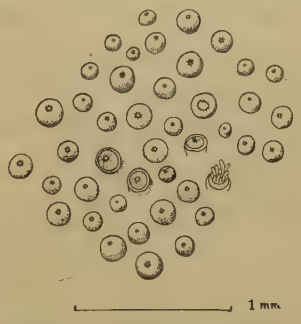


Fig. 2. *Alcyonidium sagamianum* sp. nov. Surface view of the colony with crowded mamillae.

Zooecia: The autozooecia are arranged in a peripheral layer, each disposing radially at right angles to the external surface. Each of them is slender and elongated, extending straight to some depths, or slightly oblique at its basal half. The zooecial orifice opens at the summit of the minute mamilla and the external interspaces between mamillae are filled with conspicuous thick layers. The vestibule and the atrium are distinct; the tentacles are stout, 20 in number. The alimentary canal is somewhat complicated and distinctly elongated.

Kenozooecia: The central part of the columnar branch is composed of many kenozooecia, arranged longitudinally or obliquely along the axis. The walls of them are conspicuously thickened and their cavities are usually empty in the axial part, and

provided with brown bodies or degenerated tissues in the outer part of the medulla.

Remarks: The peculiar shape and colour of the zoarium will make easy to distinguish the present species from any of the other known species of *Alcyonidium*. It is more or less closely allied to *Al. gelatinosum* in its polylamellar colony with crowded frontal mamillae supporting zooecial apertures. The shorter zooecia, more closely distributed mamillae and soft and transparent nature of the zoarium are the distinguishing characteristics of *Al. gelatinosum*. In the allied form *Al. verrilli*, the zooecia are short and stout and situated obliquely to the surface, and the zooecial walls are clearly visible among mamillae. In comparing the photographs of OSBURN (1912, pl. 31, figs. 92, 92a) with those of the present species, one will be satisfied to the separation of these two species. *Alcyonidium polypylum* is another species developing into the cylindrical zoarium, but its cross section is quite different in showing much smaller and numerous partitions.

Specimen examined: No. 8316 (Biological Laboratory, Imperial Household, Coll. Bry. No. 35). 1 mile west of Kameki-shô, off Nagai, Kanagawa Prefecture. 54–55 m. January 14, 1933. Two complete colonies and several fragments. A colony is 12,5 cm in height, and its three branches are 7.5, 7.2 and 4.5 cm in length respectively. The largest diameter of the stem is 1.4 cm and that of the branches is 1.2 cm. (Type) Another colony is 14.2 cm in height and 1.6 cm in maximum breadth, but with shorter branches.

Alcyonidium kurilensis sp. nov.

(Pl. X, Fig. 4, Pl. XI, Figs. 4–6)

Zoarium: The zoarium is erect, palmate or lobate, thick, tough and rough to the touch. The margin of the lobate body extends into several branches. The surface of the colony is thickly covered by innumerable number of short branched spines which emanate from distinct kenozooecia. The thickened branches are composed of two opposite layers of zooecia and rather thin kenozooecial medullary axis. Zooecial borders are difficult to observe in frontal view.

Zooecium: The zooecia are distinguished into two types, the larger and the smaller. The larger type of zooecia is arranged in two opposite layers separated by axial medullary layer, turning their proximal ends to each other. Their cavities are conspicuously large and sac-like, containing large polypides. The smaller type of zooecia is situated among the larger ones. Some of them are usually crowded at the lateral margin of the flattened zoarium, arranged in some radiating rows. They seem to be young, developing zooecia filling up the interspaces between the distal parts of the sac-like zooecia. These arrangements are shown in Pl. XI, fig. 4.,

Kenozooecia: The thin median medullary layer of the branch is composed of a number of flattened kenozooecia, arranged longitudinally along the zoarial axis. Their walls are not much thickened. Sometimes one or two sac-like, oval kenozooecia containing an egg are observed among the medullary zooecia (Pl. XI, fig. 5).

Spines: Spines are numerous and small. Each of them extend from a peculiar small kenozooecium with no aperture. It is chitinous, hollow and filled with tissues. The end of the spine is usually divided into two or three branches.

Remarks: The circular orifice with no chitinized lips of this species is distinctly of *Alcyonidium*, but the chitinous hollow spines are commonly met with among the species of *Flustrella*. I am now inclined to place the present species in *Alcyonidium* because of the important character of its orifice.

The general appearance of the zoarium is close to *Al. verrilli*, but in that species the zooecial aperture opens on the distinct mamilla, and the zooecial borders are quite distinct in frontal view, and the spines are absent. The present species shows general resemblance to *Flustrella vegae* from Bering Sea, but differs clearly in the *Alcyonidium*-type of its orifice, the branched, cervicorn spines, and the broader palmate zoarium.

Alcyonidium cervicornis from Alaska shows some resemblances to the present materials. It has similar apertures placed among numerous cervicorn spines emanating from smaller kenozooecia, but it differs in the zoarial characters and mamillated nature of the orifice.

Specimen examined: No. 4011. K. KURONUMA Coll. near Alaid Channel, Northern Kuril Is. 30–40 fathoms. Several large fragments of a colony, without attaching base, 10～30 mm in breadth and 3～5 mm in thickness. (Type)

Flustrella stolonifera (OKADA) 1921

(Pl. XII, Figs. 1–4; Text-fig. 3 A, B.)

Flustra stolonifera OKADA, 1921, Annot. Zool. Jap., **10**, 3, p. 19, text-fig. 1a-e.

Zoarium: The colony is conspicuous, erect, branched, bilamellar, reddish brown or pale brown in preserved specimens. The numerous, flustroid shoots emanate from a flat, unilamellar, attaching base of considerable width spreading over the substratum. The grown-up colony gives a somewhat bushy appearance.

The spreading base is also composed of many divided lobes extending closely side by side. The branching is dichotomous. The surface of the branch is beautiful with regularly arranged zooecia, and distinct cervicorn spines scattered here and there on the flattened shoot.

Zooecia: The zooecia are arranged in two opposite layers and there is no medullary structure between the two layers. The zooecia are regularly elongate

hexagonal or quadrangular, separated by rather thick walls clearly seen in frontal view. A pair of small, triangular spines are situated laterally to the zooecial aperture, and sometimes another pair of spines are observed situating a little proximally to the former, but no more spines of the same kind are observed on the zooecial borders. The large cervicorn spines emanate at the middle of the large kenozooecia which are almost the same size as the autozooecia. The aperture is transverse, slit-like with distinct chitinous proximal lip.

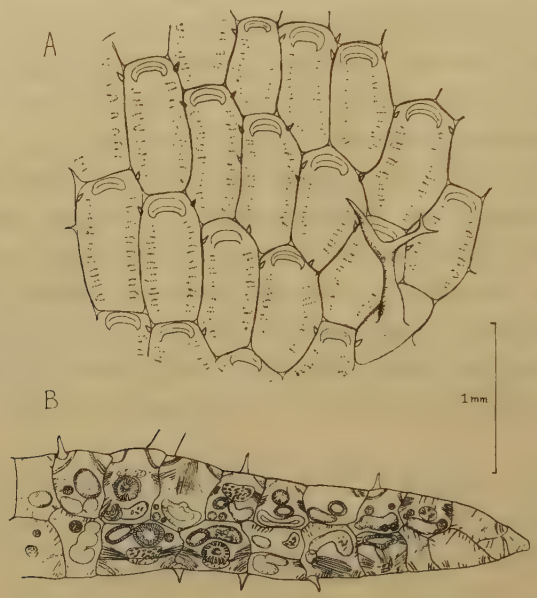


Fig. 3. *Flustrella stolonifera* (OKADA). A. Surface view of a stem. B. Transverse section of a branch.

Polypide: The polypide is large, with rather short and thick tentacle sheath situating obliquely in the rectangular zooecial cavity. The alimentary canal is somewhat developed. The coecum and intestine are conspicuously large and prominent. The parietal muscles extremely developed and often can be seen in frontal view.

The parieto-diaphragmatic muscles extremely developed.

Remarks: The species of *Flustrella* have long been known only in the encrusting form, and HARMER retained *Elzerina* with some doubt for erect branching forms. In 1947 SILÉN described two new species of *Flustrella* with erect, branching zoarium from the "Vega" collection in 1879 in Bering Sea, which preserved in the State Museum of Natural History, Stockholm. Thus there seems remain no more reason to retain *Elzerina*, if it does not take another limitation. Both of SILÉN's species have some affinities with the present species.

Fl. gigantea resembles in its large, distinct zooecia, cervicorn spines and branched colony but it is easily distinguished from the present species in the following characteristics:—(1) The colony is repeatedly bifurcated and branches are in one plane forming a fan. (2) autozooecia are not in immediate contact, but separated by a series of small kenozooecia, each bearing a tree-shaped spine.

F. vegae differs from the present form in having numerous single spines emanating from distinct kenozooecia surrounding the autozooecia.

The young, growing margin resembles much that of *Flustrella hispida* in having a small number of short spines, but the present form differs from that species in the zoarial structures, and the presence of the large cervicorn spines. *Flustrella corniculata* seems to be close to the specimens at hand, but the kenozooecia supporting the triangular spines are very conspicuous and larger than those of the present form. In my opinion there seems to be some confusions in the limitation of *Fl. corniculata.* I cannot share the opinion to include *Alcyonidium cervicornis* into *Fl. corniculata.* The former differs distinctly from the latter in having circular apertural fold, and large cervicorn spines emanating from distinct large kenozooecia, and no small, triangular spines of the different kind.

The present form was described by Y. Okada under the name of *Flustra stolonifera,* as a member of the Flustridae, but, in my opinion, it belongs not to Cheilostomata but to Ctenostomata. He described the zooecia to be small, somewhat rounded, distinctly raised, but figured none of them. I could never find them in the fully developed individuals. The present species, therefore, is interesting to give an instance showing close affinities between the Cheilostomata and the Ctenostomata.

Specimen examined: No. 7745 (Biological laboratory, Imperial Household, Coll. Bry. No. 11). Hayama, Shore, July 23, 1929. A large bushy colony attached to the root of sea weed. The erect branch is 5–11 cm in height and 5–6 mm in breadth.

No. 7792 (Biological Laboratory, Imperial Household, Coll. Bry. No. 9). Hayama, Shore, July 14, 1929. A bushy colony with short branches measuring only 1–3 cm in height and 3–5 mm in breadth.

Flustrella stolonifera var. *aspinosa* var. nov.

(Pl. XII, Fig. 5.)

Zoarium: The zoarium is lobate or palmate, attaching to substratum by an expanded unilamellar base. The erect part is bilamellar, with distinctly bordered zooecia arranged in somewhat distinct series differing from the above-mentioned species. The colour of the zoarium in the preserved state shows dark brownish in formalin and pale grayish in spirit.

Zooecia: The large cervicorn spines completely wanting. The aperture is narrow with thin lips.

Remarks: The present form is very close to *Flustrella stolonifera*, but the zoarial characters and the complete wanting of carvicorn spines seem to be enough to erect a new variety.

Specimen examined: No. 5418. MAWATARI Coll. Kurihama, Kanagawa Prefecture. Shore. August 12, 1945. A bushy colony, 2 cm in height.

No. 9037. MAWATARI Coll. Jogashima, Kanagawa Prefecture. Shore. August 20, 1953. Numerous colonies attached to the holdfast of a seaweed, 2–4 cm in height. (Type)

EXPLANATION OF PLATES X–XII

PLATE X

Fig. 1. *Alcyonidum erectum* SILÉN. ×1
Fig. 2. Do. Another colony. ×1
Fig. 3. *Alcyonidium sagamianum* sp. nov. ×1
Fig. 4. *Alcyonidium kurilensis* sp. nov. ×1

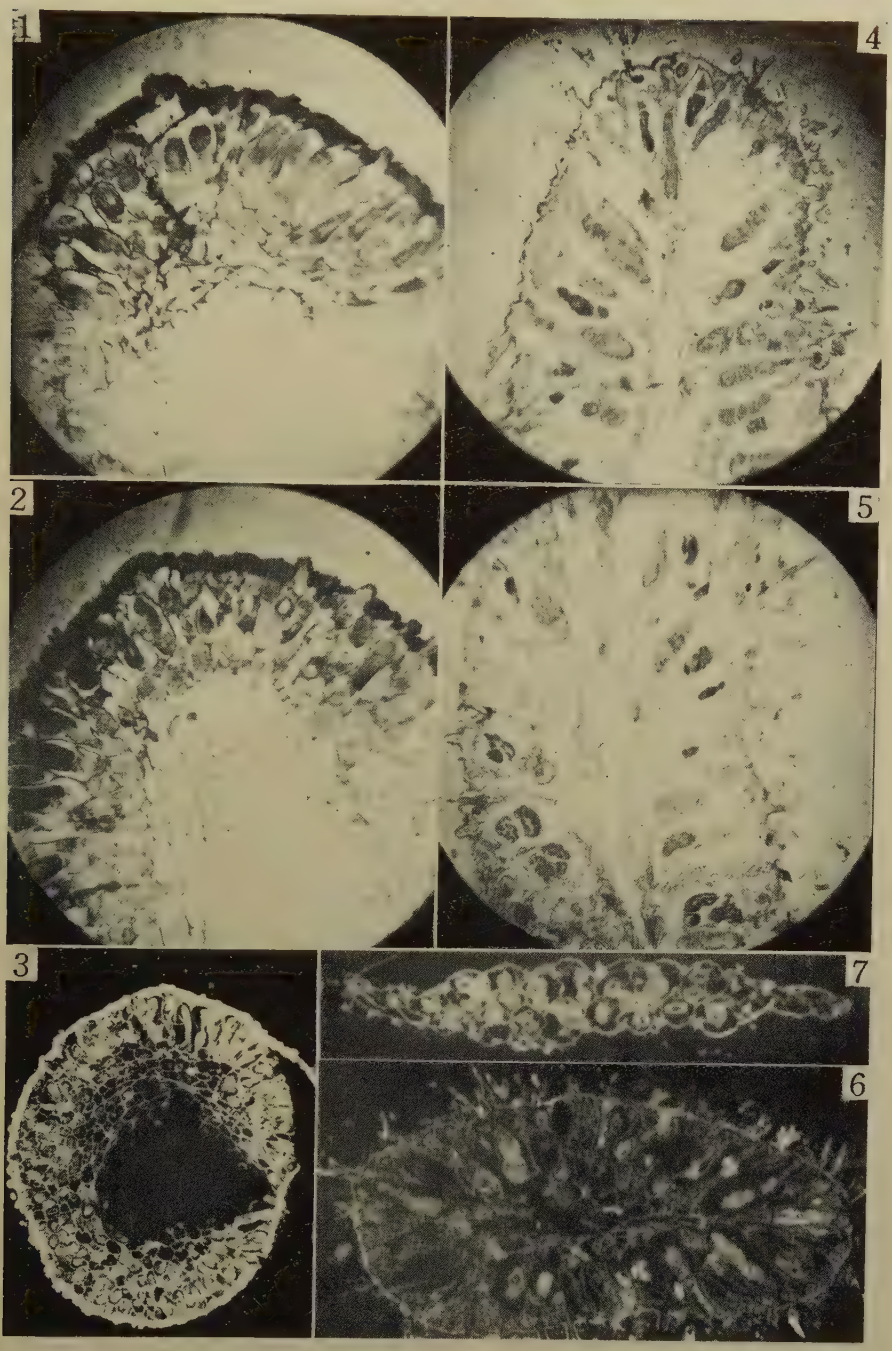
PLATE XI

Fig. 1. *Alcyonidium sagamianum* sp. nov.
Transverse section of tip of branch. ×40
Fig. 2. Do. Transverse section of stem. ×40
Fig. 3. Do. Transverse section of branch. ×10
Fig. 4. *Alcyonidium kuriliensis* sp. nov.
Transverse section of marginal part. ×40
Fig. 5. Do. Transverse section of median part. ×40
Fig. 6. Do. Transverse section of tip of branch. ×20
Fig. 7. *Alcyonidium erectum* SILÉN.
Transverse section. ×20

PLATE XII

Fig. 1. *Flustrella stolonifera* (OKADA). × 1
Fig. 2. Do. Longitudinal hand section. ×40
Fig. 3. Do. Transverse section of tip of branch. ×40
Fig. 4. Do. Transverse section of stem. ×40
Fig. 5. *Flustrella stolonifera* var. *aspinosa* var. nov. ×12

S. MAWATARI : STUDIES ON JAPANESE CTENOSTOMATA. I.



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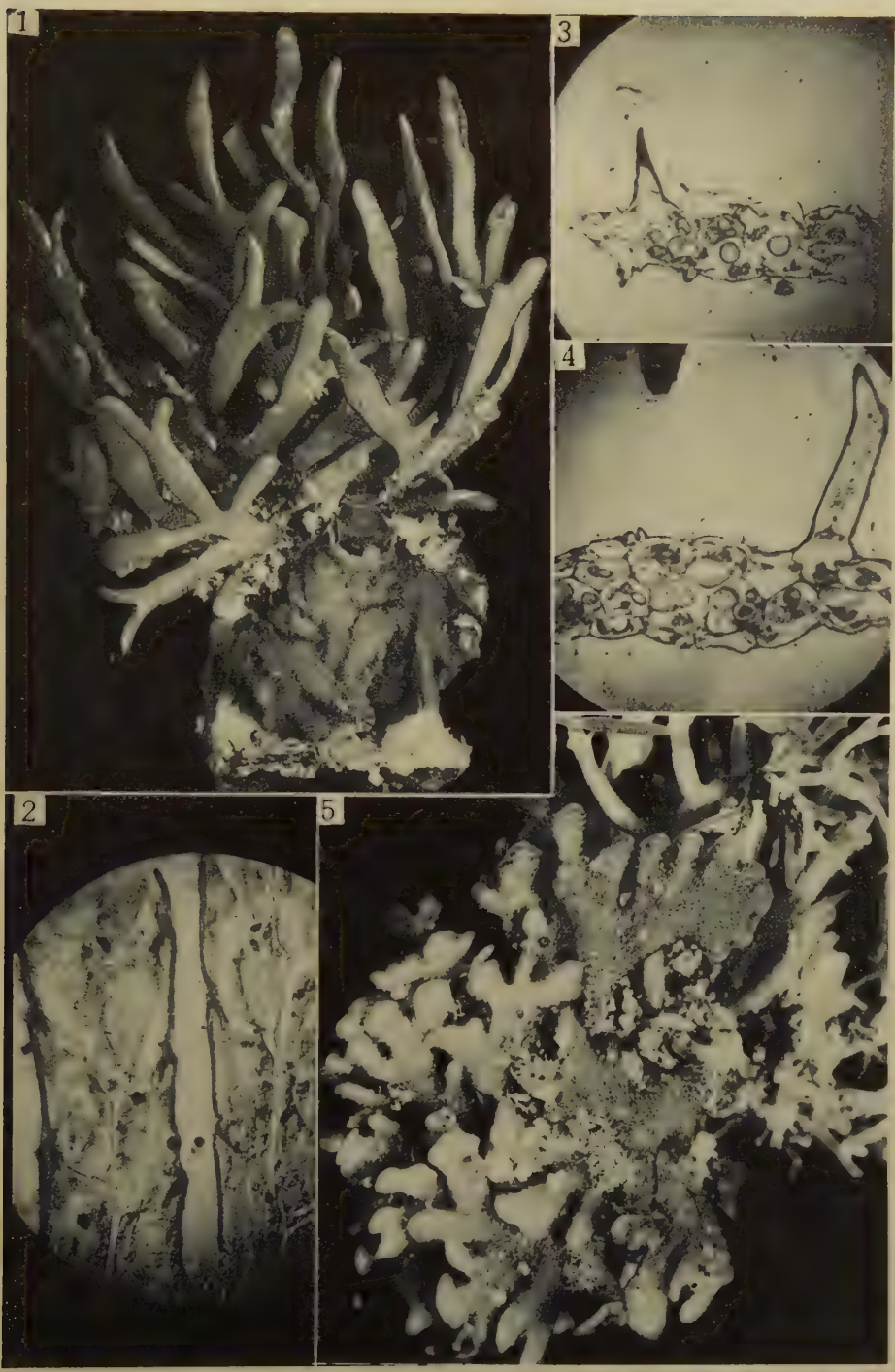

S. Mawatari : Studies on Japanese Ctenostomata. I.

PARASITIC COPEPODS FROM FISHES OF JAPAN
PART 7. CYCLOPOIDA, III AND CALIGOIDA, IV

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With Plates XIII–XVII (1–5)

CONTENTS

ERGASILIDAE
1. *Ergasilus fidiformis* n. sp. 221
BOMOLOCHIDAE
2. *Bomolochus leptoscari* n. sp. 222
3. *Bomolochus cypseluri* n. sp. 224
DICHELESTIIDAE
4. *Hatschekia diodontis* n. sp. 225
5. *Hatschekia nahaensis* n. sp. 226
6. *Hatschekia pseudolabri* n. sp. 227
7. *Hatschekia ostracii* n. sp. 228
LITERATURE 229
EXPLANATION OF PLATES 230

ERGASILIDAE

1. *Ergasilus fidiformis* n. sp.

(Pl. I. Figs. 1–8)

Habitat. Gills of *Sarcocheilichthys variegatus* (TEMM. et SCHLEG.), *Leuciscus hakonensis* GÜNTHER, *Pseudorasbora parva* (TEMM. et SCHLEG.), *Pseudoperilampus typus* BLEEKER.
Locality. Tutiura, Ibaragi Prefecture.

Body 0.68–0.85 mm long. Cephalothorax violin-shaped, 0.375–0.45×0.22–0.26 mm, with a distinct constriction on each side at the junction of the head with the first thoracic segment which is just as broad as, or only slightly narrower than, the head; front end truncate conical. Second to fourth thoracic segments short, diminishing in breadth posteriorly with following measurements respectively: 68–85×150–160μ, 55–75×110–125μ and 38–50×65–75μ. Fifth segment flattened, about 10μ long by 60μ broad. Genital segment 75–80μ long by 65–75μ broad, with maximum breadth near its anterior end. Abdomen 75–100×40–50μ, 3-segmented, pectinated along ventral

posterior margin of each segment; segments diminishing in length posteriorly (33μ, 24μ and 21μ in respective length in the type). Caudal rami cylindrical, 33–36×15–17μ, each with a very long and a shorter, terminal bristle besides two minute setae on posterior ventral margin. Egg tubes 0.25–0.6 mm long by 0.11–0.15 mm broad, each containing a few longitudinal rows of eggs.

First antenna 6–segmented, moderately setigerous, tipped with three long setae; three distal segments together only slightly shorter than three proximal segments together (21 : 24μ). Second antenna a little shorter than cephalothorax, 5–segmented; first segment short, second curved outward, without bulge, third the longest, fourth and fifth forming together a falcate claw measuring about 130μ along concave margin as in *Pseudergasilus parasiluri* YAMAGUTI, 1936. Mandible 2–segmented; basal segment with a pectinate spiniform process on posterior margin; terminal segment small, pectinated on inner margin and tip. First maxilla with two setae. Second maxilla with shaggy tip. Maxilliped lacking.

Rami of first to fourth legs 3–segmented except fourth exopod which has but two segments. They are armed with spines and setae as follows:

First exopod 1–0, 1–1, 2–5; endopod 0–1, 0–1, 2–4.
Second exopod 1–0, 0–1, 0–6; endopod 0–1, 0–1, 1–4.
Third exopod 1–0, 0–1, 0–6; endopod 0–1, 0–1, 1–4.
Fourth exopod 0–1, 1–4; endopod 0–1, 0–1, 1–3.

Fifth leg rudimentary, tipped with two fine setae.

The present species is most closely related to *Ergasilus versicolor* WILSON, 1911, but differs from it in body size, in the truncate cephalothorax, in the falcate claw of the second antenna being distinctly 2–segmented (1–segmented in WILSON's species), in the armature of each thoracic leg, etc.

BOMOLOCHIDAE

2. *Bomolochus leptoscari* n. sp.

(Pl. I, Figs. 9–11; Pl. II, Figs. 12–18)

Habitat. Gills of *Leptoscarus japonicus* (CUV. et VALENC.).
Locality. Hamazima, Mie Prefecture.
Material. One gravid female.

Body 1.15 mm long. Cephalothorax hemispherical in dorsal view, 0.41×0.575 mm, with a slightly convex frontal margin projecting beyond base of first antenna. On the midventral side of this frontal plate is a pair of short posterolaterally directed, broad-based spines 21μ long. Second to fifth thoracic segments free; second and third segments with rounded sides, 0.175×0.6 mm and 0.15×0.525 mm respectively; fourth

segment 0.125×0.275 mm, fifth segment only 60μ long, with its side produced posterolaterally to form the base for the fifth leg. Genital segment 100×177μ, bulging out laterally immediately in front of the point where the egg sacs are attached. Abdomen tapering posteriorly, consisting of three segments measuring 45μ, 30μ and 42μ in respective length. Caudal rami 33×25μ, with one seta on dorsolateral margin and four setae at distal end. The longest caudal seta is 0.32 mm in length. Egg case plump, 0.6×0.225 mm, eggs polygonal, comparatively large.

First antenna projecting slightly beyond lateral margin of cephalothorax; three proximal segments fused, with a transverse row of 14 plumose setae besides 9 simple setae (3 ventral, 5 anterior and 1 dorsal), fourth segment with three setae, fifth with three setae, sixth with one marginal and seven terminal setae. Terminal segment of second antenna covered ventrally like a file with several rows of minute comb-teeth extending from its proximal end to tip of blunt-pointed terminal process; a subterminal claw-like seta, a subterminal pectinate process, and five bundled claw-like setae are present as usual. Mandible with simple straight cutting blade. First maxilla with three setae; paragnath forming a blunt-pointed process which is finely pectinated along the posterior and distal anterior margin as well as on the tip. Second maxilla terminating in a bilaterally pectinated blade, with a smaller pectinate palp. Labium with a few transverse rows of minute spiniform teeth. Terminal claw of maxilliped S-shaped, with a curved blunt process on posterior curve. Rami of first to fourth legs 3-segmented,* armed with spines and setae as follows:

First exopod 1–0, 1–0, 2–6; endopod 0–1, 0–1, 0–5.

Second exopod 1–0, 1–0, 3–2; endopod 0–1, 0–0, 0–3.

Third exopod 1–0, 1–0, 3–2; endopod 0–1, 0–0, 0–2.

Fourth exopod 1–0, 1–0, 3–0; endopod 0–0, 0–0, 0–2.

Strictly speaking all the "spines" of the exopods are setiform. The fifth leg rod-shaped, 105×48μ, covered with exceedingly small spines at inflated part on anteroventral margin and at distal end of posterior margin, tipped with 2 setae and a short hair.

This species differs from the most closely related *Bomolochus decapteri* YAMAGUTI, 1936, in possessing no chitinous hook on the first antenna and no modified maxillary hook behind it, in the structure of the mandible and first maxilla, in the armature of the legs, etc.

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* Middle segment of first exopod partly fused with distal segment.

3. *Bomolochus* (*Artacolax*) *cypseluri* n. sp.

(Pl. II, Fig. 19; Pl. III, Figs. 20–27; Pl. IV, Fig. 28)

Habitat. Gill of *Cypselurus agoo* (TEMM. et SCHLEG.)
Locality. Hamazima, Mie Prefecture.
Material. A single gravid female.

Body 2.4 mm long, cephalothorax 0.8 mm long by 1.25 mm broad, frontal plate saddle-shaped, dorsal median chitinous rod with a pair of short side branches; lateral margins sloping anteriorly but rounded posteriorly; posterior margin slightly convex. Second thoracic segment 0.725 mm broad, well rounded at the sides, third 0.58 mm broad, overlapping the fourth dorsally so as to entirely conceal it, fifth 0.125×0.31 mm.

Genital segment 0.25×0.34 mm, enlarged at the sides where the egg sacs are attached. Abdomen 3-segmented, tapering posteriorly; first segment 0.21×0.24 mm, second 0.15×0.21 mm, third 0.14×0.18 mm. Caudal rami subcylindrical, 0.12 mm long by 54μ broad at base, with one seta on outer margin, another on dorsal side near posterior end, still another on inner margin close to two terminal setae, of which the inner is 0.525–0.538 mm long and the outer 0.14 mm long. Egg case sausage-shaped, 1.3–1.4×0.26–0.31 mm; eggs polygonal, multiseriate.

First antenna reaching a little beyond lateral margin of cephalothorax. Three proximal segments fused, with a row of 12 plumose setae, of which the distal two are on the ventral side, the others along the anteroventral edge; fourth segment with four setae, fifth with three at distal end, sixth with one subterminal and seven terminal setae, of which one is 0.21 mm long but the others, especially the dorsal, are minute. Dorsal to the base of the first antenna is a chitinous projection bearing a seta and two spines with delicate tip. Unarmed accessory antennule present, between base of first antenna and anterolateral corner of cephalothorax. Modified maxillary hook as observed in *Bomolochus decapteri* mihi is also present. Distal segment of second antenna covered ventrally with several irregular rows of spines, produced into a blunt-pointed process with five rows of spines ventrally. Besides this terminal process there are five claw-like terminal setae close together, one seta and one pectinate styliform process subterminally. Mandible with a straight terminal blade 60μ long and subterminal palp 25μ long. First maxilla with one simple and three plumose setae; paragnath cheliform, densely haired on anterior, more strongly chitinized ramus. Second maxilla terminating in a pectinate blade, with a narrower pectinate palp. Immediately posteromedial to the base of the second maxilla arises on each side a stout, blunt-pointed, chitinous rod directed posteroventrally and medially. Maxilliped terminating in a S-shaped claw with a plumose seta close to the base.

Exopod of first leg indistinctly 3-segmented; proximal segment bearing a spine

with a thick rod-shaped base, middle segment compressed, with a slender seta, distal segment with one minute simple seta and six large plumose seta along its rounded margin; endopod 3–segmented, with one plumose setae along its rounded margin; endopod 3–segmented, with one plumose seta for each of proximal and middle segments and 5 for distal segment. Second to fourth legs with 3–segmented rami, armed with setae and spines which are provided with a minute seta at the tip, as follows:

Second exopod 1–0, 1–1, 3–6; endopod 0–1, 0–2, 2–3.

Third exopod 1–0, 1–1, 2–6; endopod 0–1, 0–2, 2–2.

Fourth exopod 1–0, 1–1, 2–6; endopod 0–1, 0–1, 2–1.

Fifth leg 2–segmented, proximal segment short, not pectinated, with a seta on dorsal side, distal segment rod-shaped, 0.21–0.22×0.075 mm, with one subterminal and three terminal setae.

This species differs from the most closely related *Bomolochus* (*Artacolax*) *saetiger* WILSON, 1911, from the American flying fish in the relative length of the third abdominal segment, the shape of the caudal rami, the smooth cutting blade of the mandible, the structure of the paragnath, the armature of the legs, etc.

DICHELESTIIDAE

4. *Hatschekia diodontis* n. sp.*

(Pl. IV, Fig. 29–34)

Habitat. Gills of *Diodon holacanthus* LINNÉ.
Locality. Naha, Okinawa.
Material. Numerous gravid females.

Body 1.0–1.2 mm long, with large pigment dots scattered dorsally. Head approximately rounded triangular, 0.35–0.41×0.42–0.5 mm, flat in front and rounded behind; dorsal chitinous framework T–shaped, with distinct median sinus in front; median rib simple, fairly long, tapering posteriorly. Trunk elliptical, 0.8–1.0×0.3–0.475 mm, with maximum breadth in front of its middle. Abdomen nodular, 90–108μ in transverse diameter. Caudal rami plump, constricted at base, 27–32×15–18μ, with four setae at tip and another on dorsolateral margin. Egg string 0.65–0.96 mm long, containing a series of 8–13 eggs.

Frontal plate with a blunt-conical process on each side ventral to base of first antenna. First antenna not very distinctly 5–segmented, about 0.25 mm long, with a row of 14 fragile setae along anteroventral margin, and 12 setae at tip. Second

* This species and the next are included in the Japanese fauna, though the locality where the material was collected is now outside the Japanese territory.

antenna 2-segmented, distal segment comparatively long (135μ along concave margin), with a sharp pointed spiniform barb near proximal end and an inconspicuous thickening on concave margin of strongly curved distal portion. Maxilla with two setae on each ramus. Mandible slender, with six very minute teeth. Maxilliped 4-segmented and bifid at tip as usual; second segment as long as third, with a seta at proximal end. There are only two pairs of thoracic legs. No chitinous rods on transverse bar connecting two legs of each pair.

First exopod 2-segmented, twice as long as endopod; proximal segment with one seta at distal corner, distal segment with six setae. First endopod 1-segmented, with four terminal and two subterminal setae. Second exopod 2-segmented; with a large seta at prolonged distal corner, distal segment with five setae. Second endopod 2-segmented; proximal segment with one seta at inner distal end, distal segment with three terminal and two subterminal setae.

This species bears a superficial resemblance to *Hatschekia monacanthi* YAMAGUTI, 1939, in general body shape, but differs from it in the structure of the dorsal chitinous framework, in the relative length and structure of the two segments of the second antenna, in the exopods of each leg being 2-segmented, etc.

5. *Hatschekia nahaensis* n. sp.

(Pl. IV, Figs. 35–37; Pl. V, Figs. 38 & 39)

Habitat. Gills of *Abudefduf* sp.
Locality. Naha, Okinawa.
Material. 2 gravid females.

Body 1.6–1.75 mm long. Head approximately septangular in dorsal view, 0.3×0.44 mm, with the truncate front bordered by a transverse row of seven tubercles, of which the median corresponds to the dorsal hump of the frontal plate and the other three on each side are nodular swellings of the proximal anterior margin of the first antenna. Neck 0.25 mm broad. Trunk elliptical, 1.3–1.45 mm in length, with maximum breadth of 0.55–0.575 mm just behind its middle with a rounded (75μ in diameter) submarginal protuberance projecting outward between the first and the second leg. Abdomen semicircular, with a small (35μ in diameter) rounded midventral protuberance behind anal opening. Caudal rami plump, 20×14μ, with a very minute seta on dorsolateral margin, a longer one on inner margin, and four short ones at tip, the innermost terminal seta swollen at base to a diameter of 12μ. Egg string 1.15–1.5×0.13–0.18 mm, each containing a series of 14–28 eggs.

First antenna indistinctly 5-segmented; each of the three proximal segments has a hemispherical swelling at the anterior margin and gives the front a beaded appearance. Between the second and the third swelling is a forwardly directed,

acutely pointed seta; the fourth segment has one seta ventrally, the fifth, however, has 13 setae of varying length and thickness, mostly at the tip and on the ventral side. Second antenna 2-segmented; proximal segment with dotted appearance like a fine file except on the anteroventral side, strongly curved distal segment with similar structure at base except on the papillary swelling on the inner side. Maxilla 2-lobed, each lobe bearing two setae. Mandible slender, with three rudimentary teeth. Maxilliped as in *Hatschekia pseudolabri*. There are two pairs of legs at the anterior part of the trunk. The endopods of the two legs are one-segmented, though the chitinized outer margin shows an interruption indicating the original segmentation, tipped with two setae. The exopods of the two legs are 2-segmented, the proximal segment with one seta at its outer distal corner, the distal segment of the first leg with two setae, that of the second leg with three setae.

This species is characterized by the peculiar structure of the proximal portion of the first antenna giving the front a beaded appearance, and by the armature of the legs.

6. *Hatschekia pseudolabri* n. sp.

(Pl. V, Figs. 40–44)

Habitat. Gills of *Pseudolabrus japonicus* (HOUTTUYN) and *Verreo oxycephalus* (BLEEKER).
Locality. Komatusima, Tokusima Prefecture.
Material. Several gravid specimens fixed in alcohol and mounted in lactophenolgelatine.

Body elongate, 1.1–1.8 mm long. Head rounded, 0.25–0.27 × 0.24–0.3 mm, dorsal chitinous framework consisting of three ribs joining together in front; a median rib bifurcating posteriorly, lateral ribs curved at nearly right angles anteriorly and posteriorly. First thoracic segment forming neck 0.1–0.14 mm broad, second fused with genital segment into fusiform trunk which is 1.4–1.6 mm in length with maximum breadth of 0.4–0.55 mm in front of the middle. The posterior end of the trunk forms a rounded protuberance dorsally. Egg strings 1.2–1.8 × 0.12–0.13 mm, each containing a series of 20–30 eggs. Abdomen rounded, 40–60μ in diameter, with a distinct median incision at posterior end. Caudal rami rod-shaped, 20–24μ long by 9–12μ broad, attached to ventral side of abdomen, with one small seta on outer margin and four setae at tip.

First antenna indistinctly segmented, measuring about 0.15 mm long along its posterior margin, with a row of 10 setae along ventral margin and a tuft of setae at tip. Second antenna 2-segmented; terminal claw sharp-pointed. Mandible slender, with four rudimentary teeth. Maxilla 2-lobed, each lobe with 2 setae. Maxilliped 4-segmented, largest second segment with an acutely pointed seta at its proximal end ventrally, third slender, as long as second, fourth bifid at tip. First two pairs of legs biramose; basipod of first leg with a seta at outer end and another just inside

base of endopod, latter seta lacking on second leg. Rami of each leg 2-segmented, armed with setae as follows:

First exopod 1, 4*; endopod 0, 2.

Second exopod 1, 2; endopod 0, 2.

Third and fourth legs lacking.

This species differs from the most closely related *H. labracis* (VAN BENEDEN), *H. leptoscari* YAMAGUTI, 1939, and *H. branchiostegi* YAMAGUTI, 1939, in the chitinous framework on the dorsal side of the head, the armature of the legs, the length of the egg strings and the number of eggs in each string, etc.

7. *Hatschekia ostracii* n. sp.

(Pl. V, Figs. 45–48)

Habitat. Gills of *Ostracion tuberculatum* LINNÉ.
Locality. Komatusima, Tokusima Prefecture.
Material. Several gravid females.

Body 0.9–1.06 mm long. Head subglobular in dorsal view, 0.35–0.41×0.31–0.36 mm, with a prominent cornuate process projecting outwards between base of second antenna and lateral edge of head. On the dorsal side there are two lateral, hammer-shaped chitinous frames with an undulating handle and an unpaired T-shaped central frame. The median place of the latter is bifurcate or trifurcate at the tip, and has a pair of slender, posterolaterally directed side branches at about its middle, each anterior lateral arm of the median frame runs along the anterior border of the head and terminates anterolateral to the posterior end of the handle of the paired hammer, it has two inwardly projecting nodular swellings, of which the anterior lies immediately in front of the head of the hammer and the posterior fits into the sinus of the handle of the hammer. There is no neck region between the head and the trunk. The trunk, attached to the head at the base of the maxillipeds, is convex at the sides, 0.3–0.4 mm in maximum breadth in front of its middle, and has a plump, backwardly directed process like that of *Hatschekia hippoglossi* (KRÖYER) of SCOTT on each side of its truncate posterior end, where it encloses the base of the genital segment to which the egg strings are attached. Genital segment 90–100μ in diameter, completely fused with inverted trapezoidal abdomen. Caudal rami rod-shaped, 33–45μ by 10–15μ, with 4 setae at tip and another on outer margin. Egg strings 0.38–0.6 ×0.15–0.18 mm, each containing a series of 4–8 eggs.

First antenna 7-segmented; first basal segment short, with one seta on ventral edge, second segment long, with one seta on anterior margin, two setae on ventral

* Including a very minute one on inner margin.

edge, other segments comparatively short, seventh with two terminal and nine subterminal setae. Second antenna 3–segmented; basal segment projecting outward in form of a conical protuberance, middle segment somewhat attenuated at middle, with bacillary markings except at proximal anterior corner, measuring 0.18 mm along concave margin; terminal segment falciform, measuring 90μ along concave margin. Maxilla with 2 setae on each lobe. Mandible slender, with 4 rudimentary teeth. Maxilliped as usual, third segment a little shorter than second. There are 3 pairs of thoracic appendages. First and second legs with 4 backwardly directed chitinous spines on each transverse bar connecting the basipods. Exopods of first and second legs 2–segmented, proximal segment slightly longer than the distal, with one seta at distal outer corner, distal segment with 4 setae. Endopods of these legs rather indistinctly 2–segmented, basal segment without setae, distal segment with 5 setae for first leg and 4 setae for second leg. Third leg a little behind the broadest part of trunk, reduced to a minute papilliform projection bearing two setae.

This species is unique in possessing a pair of cornuate processes projecting outward beyond the lateral edge of the head at the level of the basal segment of the second antenna which also projects outwards in the form of a conical process.

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EXPLANATION OF PLATES

PLATE I

Figs. 1–8. Female of *Ergasilus fidiformis* n. sp.

Fig. 1. Dorsal view of mature female. Fig. 2. First antenna.
Fig. 3. Second antenna. Fig. 4. Mouth parts.
Fig. 5. First leg. Fig. 6. Second leg.
Fig. 7. Third leg. Fig. 8. Fourth leg.

Figs. 9–11. Female of *Bomolochus leptoscari* n. sp.

Fig. 9. Dorsal view of gravid female. Fig. 10. Mouth parts.
Fig. 10. Maxilliped.

PLATE II

Figs. 12–18. Female of *Bomolochus leptoscari* n. sp.

Fig. 12. First antenna. Fig. 13. Second antenna.
Fig. 14. First leg. Fig. 15. Second leg.
Fig. 16. Third leg. Fig. 17. Fourth leg.
Fig. 18. Fifth leg.

Fig. 19. Gravid female of *Bomolochus cypseluri*, dorsal view.

PLATE III

Figs. 20–27. Female of *Bomolochus cypseluri* n. sp.

Fig. 20. First antenna. Fig. 21. Second antenna.
Fig. 22. Mouth parts. Fig. 23. Maxilliped.
Fig. 24. First leg. Fig. 25. Second leg.
Fig. 26. Third leg. Fig. 27. Fifth leg.

PLATE IV

Fig. 28. Fourth leg of female of *Bomolochus cypseluri* n. sp.

Figs. 29–34. Female of *Hatschekia diodontis* n. sp.

Fig. 29. Dorsal view of gravid female. Fig. 30. First antenna
Fig. 31. Second antenna. Fig. 32. Maxilliped.
Fig. 33. First leg. Fig. 34. Second leg.

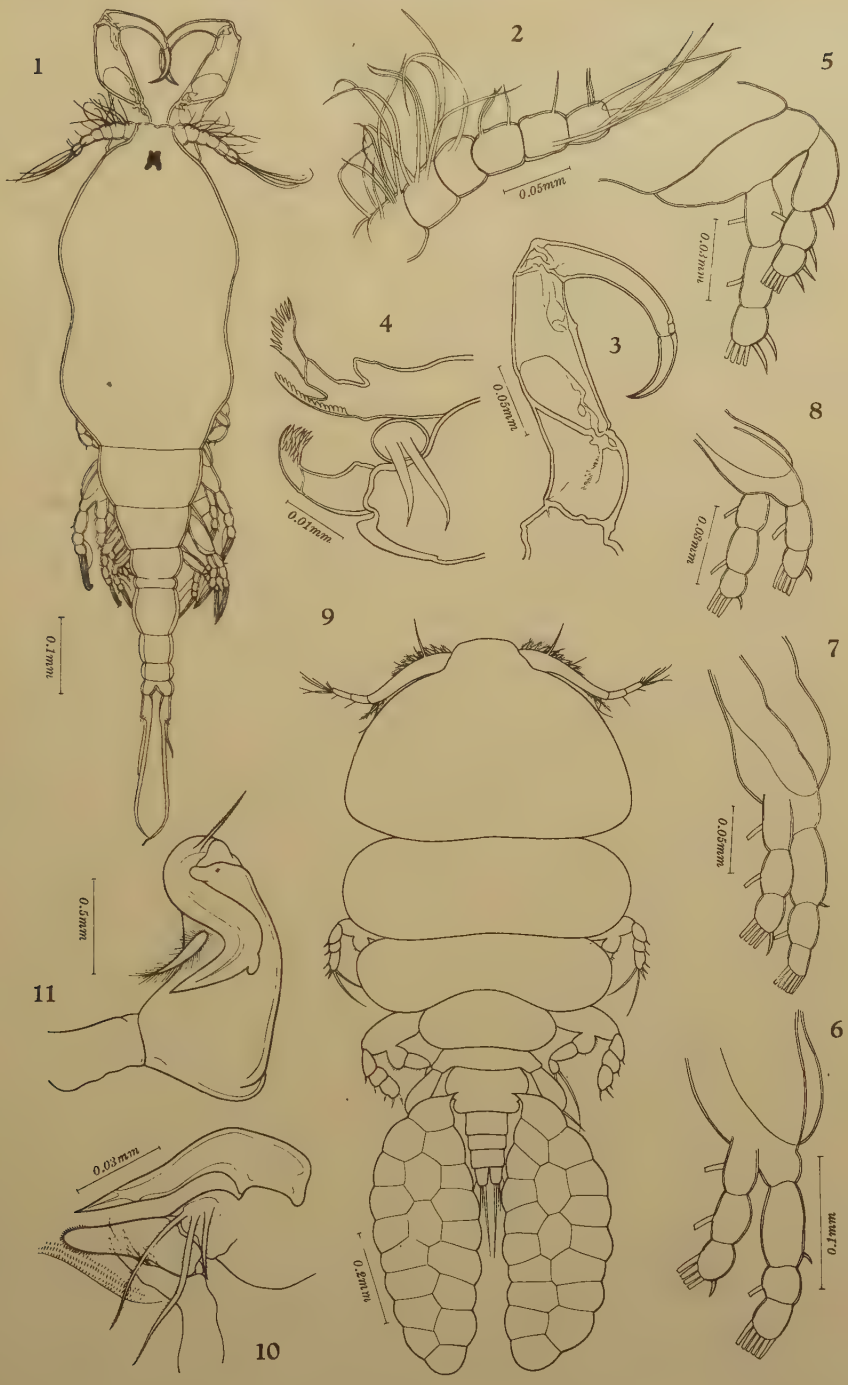
Figs. 35–37. Female of *Hatschekia nahaensis* n. sp.

Fig. 35. Dorsal view of gravid female.
Fig. 36. Second antenna. Fig. 37. First leg.

PLATE V

Figs. 38–39. Female of *Hatschekia nahaensis* n. sp.

Fig. 38. Maxilliped. Fig. 39. Second leg.
Figs. 40–44. Female of *Hatschekia pseudolabri* n. sp.
Fig. 40. Dorsal view of gravid female.
Fig. 41. First antenna. Fig. 42. Second antenna.
Fig. 43. First leg. Fig. 44. Second leg.
Figs. 45–48. Female of *Hatschekia ostracii* n. sp.
Fig. 45. Dorsal view of gravid female.
Fig. 46. Second antenna. Fig. 47. Second antenna.
Fig. 48. Second leg.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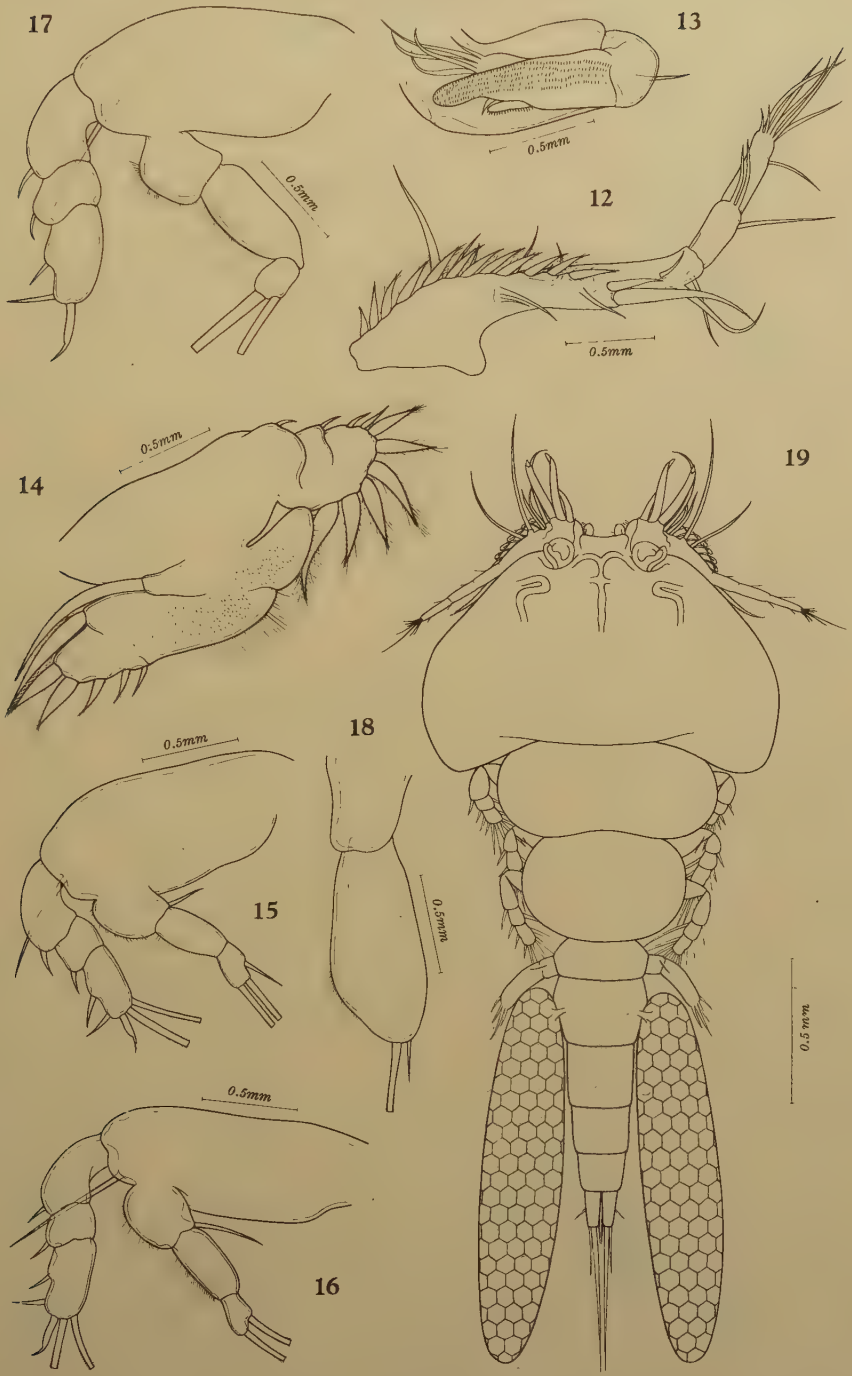
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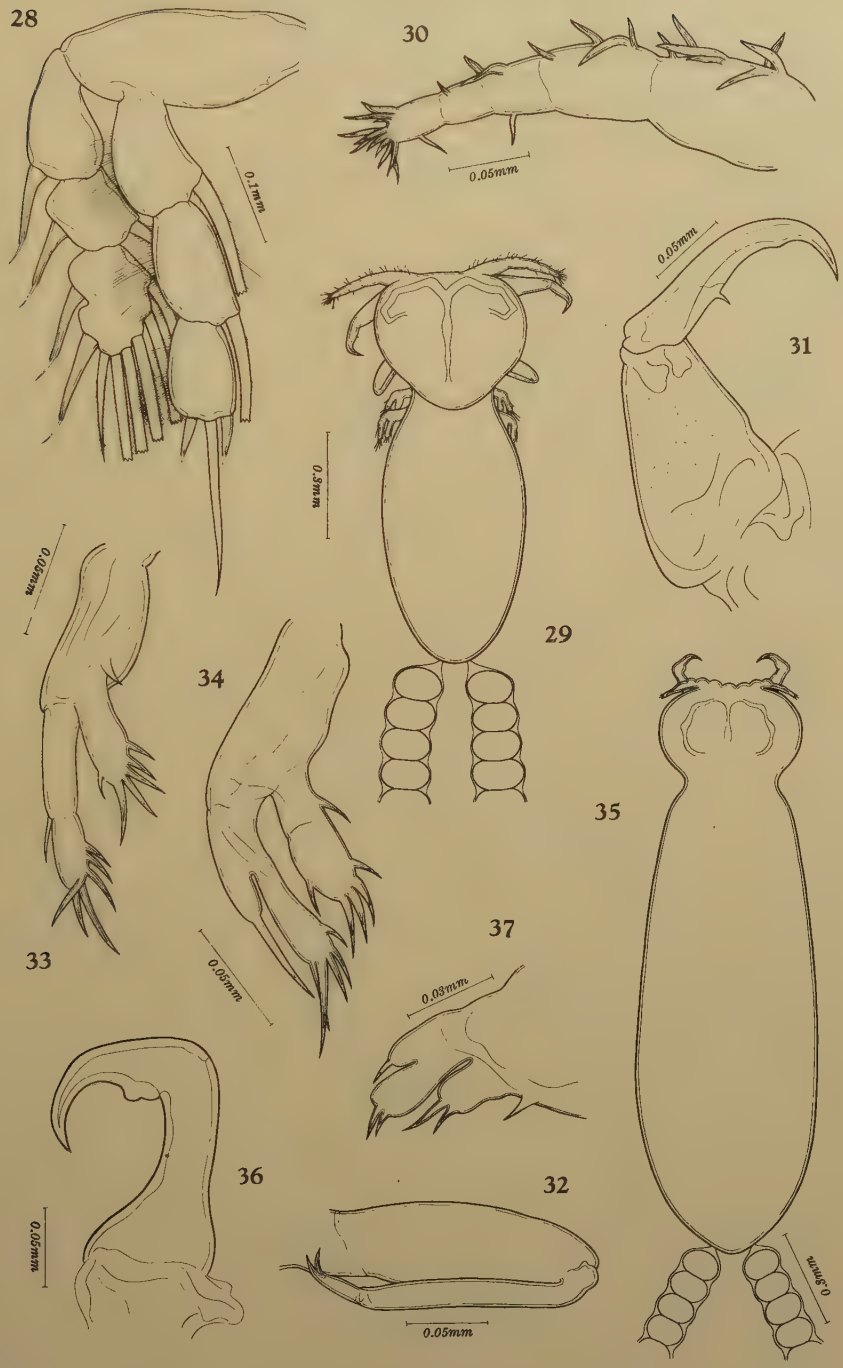
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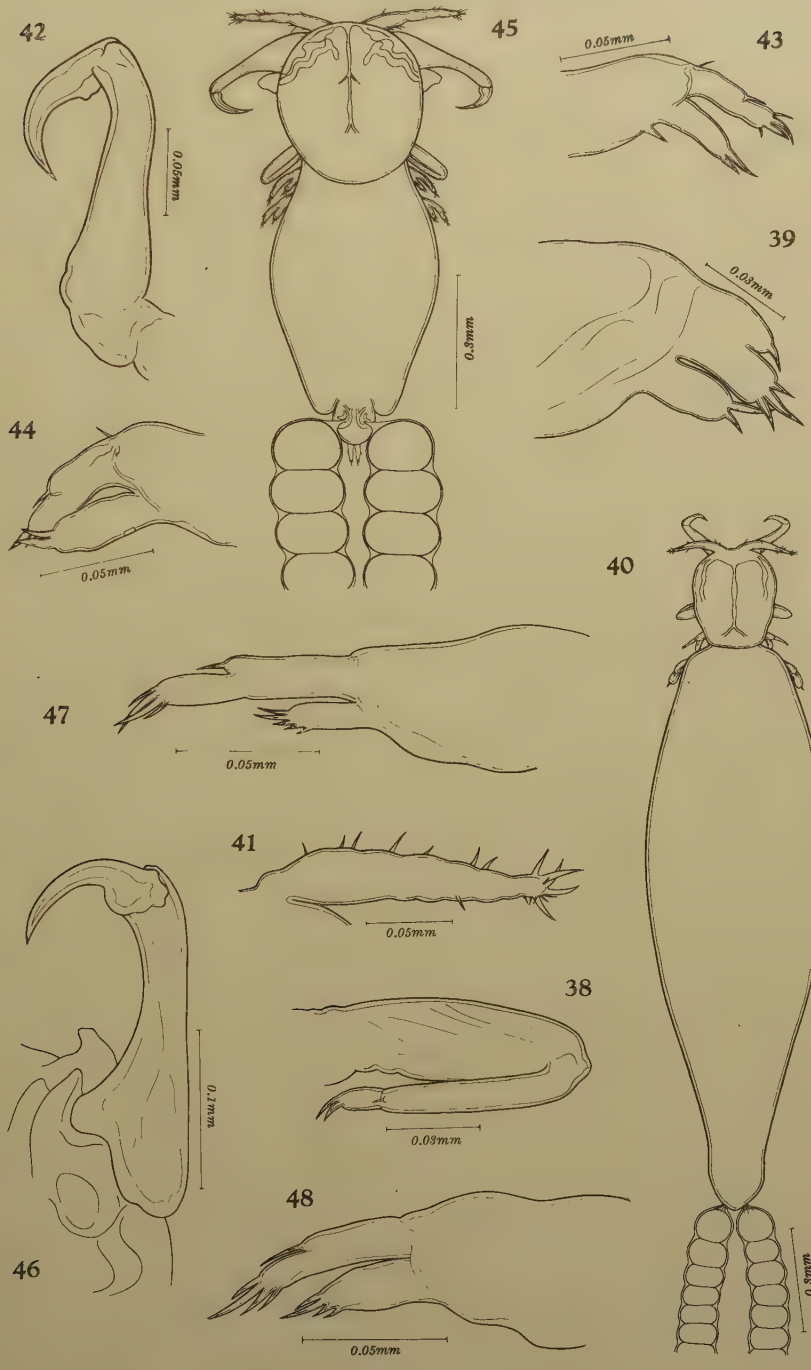
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1952 (昭和27年)

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